HUMAN BIOLOGY

a record of research

Edited by

RAYMOND PEARL

in association with

H. S. JENNINGS ADOLF MEYER ADOLPH H. SCHULTZ
CURT P. RICHTER and JOHN R. MINER

Managing Editor

BLANCHE F. POOLER

ADVISORY BOARD

ED. CLAPARÈDE
University of Geneva

CHARLES B. DAVENPORT
Carnegie Institution

S. R. DETWILER
Columbia University

E. M. EAST
Harvard University

EUGEN FISCHER
Kaiser Wilhelm Institut für Anthropologie, Berlin-Dahlem

CORRADO GINI
R. Università de Roma

MAJOR GREENWOOD
School of Hygiene and Tropical Medicine, London

SHINKISHI HATAI
Tôhoku Imperial University, Sendai

ALEŠ HRDLIČKA
Smithsonian Institution

ERNST KRETSCHMER
Universitäts-Nervenklinik, Marburg

H. LUNDBORG
Statens Institut för Rasbiologi, Uppsala

BRONISLAW MALINOWSKI
London School of Economics

D. PEYRONY
Musée Prthistorique, Les Eysies (Dordogne)

P. RIVET
Muséum National d'Histoire Naturelle, Paris

JOHN B. WATSON
New York

CLARK WISSLER
American Museum of Natural History

HUMAN BIOLOGY is published quarterly by The Johns Hopkins Press, Baltimore, Maryland, U. S. A. The advance subscription price is $5.00 a year; foreign postage 25 cents extra. Single current issues are $1.50 each; back numbers, $2.00 each; back volumes, $6.00; plus postage. Subscriptions for less than a year are charged at the single issue price.

Subscribers should notify the publishers of change in address at least two weeks before publication of the issue with which change is to take effect. No claim for non-receipt of an issue will be entertained unless made immediately upon receipt of the next succeeding issue.

Manuscripts and communications regarding editorial matters should be addressed to Editor, Human Biology, 1901 E. Madison St., Baltimore, Maryland, U. S. A.

THE JOHNS HOPKINS PRESS, *Publishers*
BALTIMORE, MARYLAND, U. S. A.

Entered as Second Class matter, February 18, 1929, at the Post Office at Baltimore, Md., under the Act of March 3, 1879.

VOLUME III 1931

HUMAN BIOLOGY

a record of research

Edited by

RAYMOND PEARL

in association with

H. S. JENNINGS ADOLF MEYER ADOLPH H. SCHULTZ
CURT P. RICHTER and JOHN R. MINER

Managing Editor

BLANCHE F. POOLER

ADVISORY BOARD

ED. CLAPARÉDE
University of Geneva

CHARLES B. DAVENPORT
Carnegie Institution

S. R. DETWILER
Columbia University

E. M. EAST
Harvard University

EUGEN FISCHER
Kaiser Wilhelm Institut für Anthropologie, Berlin-Dahlem

CORRADO GINI
R. Université de Roma

MAJOR GREENWOOD
School of Hygiene and Tropical Medicine, London

SHINKISHI HATAI
Tôhoku Imperial University, Sendai

ALEŠ HRDLIČKA
Smithsonian Institution

ERNST KRETSCHMER
Universitäts-Nervenklinik Marburg

H. LUNDBORG
Statens Institut för Rasbiologi, Uppsala

BRONISLAW MALINOWSKI
London School of Economics

D. PEYRONY
Musée Préhistorique, Les Eyzies (Dordogne)

P. RIVET
Muséum National d'Histoire Naturelle, Paris

JOHN B. WATSON
New York

CLARK WISSLER
American Museum of Natural History

THE JOHNS HOPKINS PRESS, *Publishers*
BALTIMORE, MARYLAND, U. S. A.
1931

Medical
Library

CONTENTS

No. 1, February, 1931

PAGE

Studies in Personality. A. Hypnotizability as a Personality Trait and its Typological Relations . . . . . *Herbert Barry, Jr., Donald W. Mackinnon and Henry A. Murray, Jr.* 1

The Relationship of Individual Growth to Average Growth . . . . . *Margaret Merrell* 37

Differential Mortality in the American Negro . . . . . *S. J. Holmes* 71

A Study of Like-Sexed Twins. I. The Vital Statistics and Familial Data of the Sample . . . . . *Paul T. Wilson and Harold E. Jones* 107

Notes: Longevity: A Pedigree . . . . . *Raymond Pearl* 133

Quotations: Harvey's Post-Mortem Examination of Thomas Parr 138

Recent Literature 143

No. 2, May, 1931

Life Tables for a Southern Chinese Family from 1365 to 1849 . *I-chin Yuan* 157

The Correlation Between Growth Rates of Population and Vital Factors by Geographical Districts . . . . . *Haruo Mizushima* 180

Differential Mortality in the American Negro. (*Concluded*) . *S. J. Holmes* 203

Studies on Human Longevity. IV. The Inheritance of Longevity. Preliminary Report . . . . . *Raymond Pearl* 245

A Study of Like-Sexed Twins. Part II. Their Health and Disease Records *Paul T. Wilson* 270

The Blood Groups of the Maori . . . . . *Gilbert Phillips* 282

Notes: Eugenics Research Survey . . . . . *Frank Lorimer* 288

Erratum 288

Recent Literature 289

No. 3, SEPTEMBER, 1931

PAGE

The Density of Hair in Primates . . . . . *Adolph H. Schultz* 303

Some Phases of Human Biology in Korea (Chosen) . . *Thomas J. LeBlanc* 322

The Families of Freshmen . . . . . *Raymond R. Willoughby* 342

Vital Statistics of New Ireland (Bismarck Archipelago) as Revealed in Genealogies . . . . . *Hortense Powdermaker* 351

Marriages in the State of New York with Special Reference to Nativity. . . *J. V. DePorte* 376

Racial Differences in Mortality and Morbidity . . . . . *Forrest Clements* 397

The Use of Indices as an Auxiliary Method in the Establishment of Physical Types . . . . . *Kurt Westphal* 420

Notes: Church Membership and Commitments of Prisoners . *John R. Miner* 429

Quotations: The Inhabitants of the Island of St. Kilda and Acute Upper Respiratory Disease . . . . . *William M. Gafafer* 437

Recent Literature 442

No. 4, DECEMBER, 1931

The Structure of a Growing Population . . . . . *Alfred J. Lotka* 459

Secular Changes in Mortality Rates Connected with Certain Organ Systems *Elizabeth C. Tandy* 494

Some Effects of Thyroid Disorder in Women . . . . . *L. S. Cressman* 529

Studies in Human Inheritance VI. A Genetic Refutation of the Principles of "Behavioristic" Psychology . . *David C. Rife and Laurence H. Snyder* 547

Changes in the Sex Ratio in Infant Mortality According to Age . . . . . *S. J. Holmes and V. P. Mentzer* 560

Notes: Folk Medicine in Russia . . . . . *Samuel S. Dworkin* 576

Quotations: On the Alleged Lethal Effects of Sexual Continence in the Holy Land . . . . . *Raymond Pearl* 577

Recent Literature 586

Index 601

Vol. III No. 1

HUMAN BIOLOGY

a record of research

FEBRUARY, 1931

STUDIES IN PERSONALITY

A. HYPNOTIZABILITY AS A PERSONALITY TRAIT AND ITS TYPOLOGICAL RELATIONS

BY HERBERT BARRY, JR., DONALD W. MACKINNON AND HENRY A. MURRAY, JR.

Harvard Psychological Clinic

INTRODUCTION

Since the classic controversy between the Nancy and the Paris schools of psychiatry, diverse views have been held in respect to the nature of hypnosis and the distribution of hypnotizability as a personality trait. The subject is still a matter for dispute.

It will be remembered that Liébault and Bernheim held that hypnosis was a particular state of intensified suggestibility brought about by suggestion itself, and that under the proper conditions almost everyone was hypnotizable; whereas Charcot and later Janet, his successor at the Salpêtrière Clinic in Paris, maintained that hypnotizability was a symptom of hysteria, and hence only hysterics could be hypnotized. Janet, indeed, claimed that hysterics lost their hypnotizability as they became free of symptoms. The Nancy School, on the other hand, maintained that hysteria was a manifestation of hyper-suggestibility to endopsychic stimuli, just as hypnosis was the result of hyper-suggestibility to exopsychic stimuli. In other words, for these workers suggestibility was the central concept in both phenomena.[2]

In the minds of most workers this initial problem in the controversy, about which is the cart and which is the horse as between suggestibility and hysteria, has been decided in favor of the Nancy School. Suggestibility is the more inclusive concept. For whereas under the proper conditions most hysterics are hyper-suggestible and hypnotizable, the

majority of suggestible and hypnotizable persons are without the symptoms of hysteria. That there are different forms of suggestibility which are not correlated with one another need not concern us at the moment; for we limit our discussion to that type of hyper-suggestibility—somewhat tautologically named hypnotic suggestibility—which is considered to be a genetic factor in both hypnosis and hysteria.

In the subsequent developments of the subject it was Janet who made the significant contributions. The question to be answered was this: of what form of psychic constitution is hypnotic suggestibility a manifestation? Janet [10] said a dissociable constitution; dissociability being due to the diminution of a certain force that was conceptualized as integrating the various components of the personality into a whole. He called this force psychic tension. The theory that seems most widely accepted at present is that psychic hypotension, or dissociability, is the root concept of which hypnotizability and all the symptoms of hysteria are but objective manifestations. Consequently, hyper-suggestibility or hypnotic suggestibility is a result or manifestation of a state of dissociation, which may be brought about in dissociable persons by suggestions of a certain kind or, as experience has shown, by fatigue, conflict or sudden shock. Since in ordinary life a state of dissociability is not uncommonly the outcome of a severe shock, it is the present view of Kretschmer [14] and others that, given a sufficient psychic trauma, almost anyone may develop hysteria. On the other hand, to explain how it happened that under a given psychic load, war for instance, some persons did and others did not develop hysteria, one would have to refer, among other factors, to individual differences in dissociability.

The typological correlations of dissociability in general and of hypnotizability in particular are the subject of the present investigation. Hypnotizability may be spoken of as a trait—or in our nomenclature a minor disposition—when the word is used conceptually to denote a particular more or less constant configuration of the personality which is objectified or manifested by reaction patterns of a limited type. A trait, or minor disposition, is in turn the manifestation of a functioning major disposition or of a number of confluent major dispositions. We should consider that a trait was a habitual dynamic state, partly innate and partly acquired, which might be modified within certain limits by experience and training.

TYPOLOGICAL CONSIDERATIONS

Janet went on to make a thorough and comprehensive examination of the personality of the hysteric, the account of which stands as the most concise and brilliantly ordered typological description in the literature.[8] It seemed that all the manifestations of the hysteroid type might be subsumed under the concept of psychic hypotension (dissociation).

Further studies then led Janet to make his memorable distinction between hysteria and psychasthenia.[9] The hysterics were characterized by what appeared to be disorders of the voluntary and sensory nervous systems, paralyses, convulsions, mutisms; anaesthesias and paraesthesias, blindness and deafness (positive and negative sensory presentations) and certain peculiar dissociated states, of greater or less duration, which, like sleep, were insulated from the continuity of the normal waking consciousness (conditions attended with amnesia, i.e. the absence of the sensory presentations which might be expected). The latter states took various forms: somnambulisms, fugues, *alter* personality episodes and so forth.

The psychasthenics (obsessives), on the other hand, formed a rather large and heterogeneous group characterized by a symptomatology more purely mental, which included mood and emotional disorders, such as phobias and general anxiety (emotive presentations); obsessional ideas (cognitive presentations) and compulsive forms of behavior (conative presentations).

Now it was observed that the majority of psychasthenics were not hypnotizable; a fact which led Freud to develop the procedure of free-association to replace hypnosis as a method for obtaining lost memories from patients of this group. And so it became a tacit assumption, which was never systematically proved, that hypnotizability was one criterion for differentiating the hysteric from the psychasthenic subject.

It is not our purpose to give a complete survey of the studies subsequent to Janet's which bear upon this aspect of psychological typology. As a historical and speculative background for the present research, it is only necessary for us to select from among the chief basic psychological traits or dispositions that are capable of being identified by their manifestations, those that have some relationship to either hysteria or psychasthenia.

The first of these is introversion, a concept proposed by Jung[11] to account for the personality of the schizophrenic. In his "Psychology of Dementia Praecox" Jung did not seek to make comparisons with

other personality patterns, but in his next study[12] he wrote: "Subsequent experience with Dementia Praecox, and particularly the study of Psychasthenia in Paris, have demonstrated to me the essential relationship of Janet's group with the Introversion Neuroses (the Schizophrenic of Bleuler)." When the now familiar dichotomy of extraversion and introversion was subsequently developed,[13] Jung drew attention to the similarity between introversion and psychasthenia and, as a corollary, spoke of hysteria as the typical neurosis of extraversion. At this time he also made a number of other speculative correlations between the extravert-introvert classification and certain categories proposed by previous investigators. The most notable of these was the identification of extraversion with the shallow-broad type of mental process (short secondary function) and introversion with the deep-narrow type (long secondary function) as defined by Gross.[4] The secondary function was a concept devised to explain the persistence and elaboration of a single trend of thought, a trait which was particularly noticeable in certain cases of obsessional depression. It was supposed that the psychical element, whatever it was, after its presentation in consciousness remained active (secondary functioning) and regulated further associations. A long secondary function seemed to be identical with what G. E. Müller called perseveration; and Spearman,[22] who approached the problem from a purely objective standpoint, hypothetically considered them as such. Perseveration was now defined as the lag or inertia of cognitive processes and for measuring it Spearman devised tests which showed a satisfactory degree of intercorrelation. It was thus demonstrated that a definite trait was being measured which varied markedly in degree from one individual to another. By this view perseveration as mental lag was a concept which included the 'perseveration' of G. E. Müller and the 'secondary function' of Gross and even constituted, so it was supposed, the solid core of Jung's introversion concept. Spearman also classed Stern's objective type with the extravert and his subjective type with the introvert.

A new outlook on the type problem was furnished by Kretschmer,[15] who approached it from a study of manic-depression and schizophrenia. He proposed two personality types, the cyclothymes and the schizothymes; categories which in the minds of most workers became at once associated with the extravert and introvert respectively. Notable among the followers of Kretschmer were Wertheimer and Hesketh,[24] who drew approximately the same distinction between those whose interest flowed

outward and became attached to the world of objects and people, and those whose energy remained egocentric and insulated by protective attitudes. Instead of extraversion and introversion, however, Wertheimer and Hesketh proposed for the two types the terms syntropic and ideotropic respectively. They found that these two types, as determined by an investigation of their personality histories, were correlated with manic-depression and schizophrenia, as diagnosed in the hospital.

Kretschmer correlated his cyclothymic group with certain anatomical and physiological markings which taken together formed the pyknic type (the stout, hairy, hearty physique) and his schizothymic group with what he named the asthenic type (the thin, hairless, flat-chested physique). The athletic physique stood between the two.

Wertheimer and Hesketh, on the other hand, laid more emphasis on anthropometric measurements. They came to the conclusion that the following formula:

$$\frac{\text{Chest: sagittal diam.} \times \text{antero-posterior diam.} \times \text{horizontal diam.}}{\text{Height}}$$

was the best anatomical index for differentiation. It was low in schizophrenia and high in manic-depression.

Other concepts and hypotheses have been advanced, but much of the recent work, such as that of Neymann and Kohlstedt [20] has been based upon the hypothesis that hysteria, extraversion, cyclothymia and manic-depressive insanity are in one class and psychasthenia, introversion, schizothymia and schizophrenia are in another. This hypothesis is to be reached by a combination of the results and assumptions offered by the investigators whose work has just been cited; and among others McDougall [19] seems to have tentatively accepted it.

The whole matter may be represented in the following schematic summary:

Psychotic types

Manic-depression (Kraepelin)	Schizophrenia (Bleuler)

Psychoneurotic types

Hysteria (Janet)	Psychasthenia

Personality types	
Extraversion (Jung)	Introversion
Cyclothymia (Kretschmer)	Schizothymia
Syntropism (Wertheimer & Hesketh)	Ideotropism
Short secondary function (Gross)	Long secondary function
Objective (Stern)	Subjective
Traits	
Hypnotizability	Non-hypnotizability
Non-perseveration (Spearman)	Perseveration
Anthropometric types	
Pyknic (Kretschmer)	Asthenic
$\frac{\text{Chest volume}}{\text{Height}}$ high (Wertheimer & Hesketh)	$\frac{\text{Chest volume}}{\text{Height}}$ low

This list makes a very neat set of dichotomies supposedly correlated and as a first approximation may have some speculative value. At least it should stimulate further investigations and hence modifications of the scheme based upon more sharply observed facts.

The probabilities of error in such dichotomizings, however, are obvious enough. The fact that *A* is positively correlated with *B*, and *B* with *C*, and *C* with *D*, does not allow one to conclude that *A* is positively correlated with *D*. Many elements, moreover, are correlated not with the absolute amount of one other factor but with a quantitative relationship, such as a ratio of factors. As an example let us take the hydrogen ion concentration in the blood. At one time it was considered that the estimation of base as bicarbonate could be used as a measurement of the hydrion concentration since the two were usually inversely proportional. When it was discovered that the hydrion concentration might be high (acidosis) with a high concentration of base (cf. asphyxia) or it might be low (alkalosis) with a low concentration of base (cf. overbreathing), it became evident that to know the hydrion concentration, the free acid must be measured simultaneously with the bicarbonate. In other words, the hydrion concentration was a function of the acid-base ratio. Boyle's law giving the relation of volume, pressure, and temperature is another case in point.

Such criticism based upon theoretical grounds may be supported by empirically grounded considerations which have tended to show that in

many respects the schematic correlations outlined above are untenable. Let us enumerate a few of them. In the first place, analysis revealed the fact that psychasthenia, as described by Janet, was a very heterogeneous group which included many psychotic cases. At least two psychoneurotic entities were abstracted from it: anxiety neurosis (renamed by Freud, anxiety hysteria) and compulsion neurosis. Other corrections followed. Further studies led Jung, for instance, to modify his view that schizophrenia was invariably correlated with introversion and manic-depression with extraversion.[21] Then objections were raised to the association of objectivity and subjectivity with extraversion and introversion respectively; this point of view being represented by Hinkle's [8] typological system, which differentiated six classes: simple extraverts and introverts, subjective extraverts and introverts, and objective extraverts and introverts. Finally we may mention Lundholm's [16] aggregated evidence to show that hysteria is more closely allied to schizophrenia than to the affective psychoses (manic-depression).

From this it would seem that the schema of typological formulations given above is a rather unsubstantial speculative apposition of items which are neither identical nor dependent upon a common factor. And the reader may wonder why it is that we have taken the space to discuss their development if at the end of it all we are to discard them. The reason is that we consider these preliminary classifications suggestive and, although unacceptable in their present form, directive of attention towards matters of the utmost importance to psychology. In subsequent communications we shall have occasion to refer to them.

At this point the most substantially constructive direction of effort would be the attempt to define precisely and, if possible, measure one significant trait at a time, to determine its variability and distribution amongst normals and abnormals, to correlate it with other traits at different ages and in the two sexes, and finally to determine how it is organized dynamically as part of the total personality.

Since personality is to be conceived of as a composite of dispositions which vary as to their quantitative proportions and as to their forms of functional organization in space and time, the ability to express a disposition in quantitative terms (representing intensity or protensity) is what makes a typological system possible.

The attempt so to express functionally significant traits is met by certain insurmountable difficulties. For instance, one must examine

subjects under special and perhaps unnatural conditions (cf. laboratory or consultation room) or trust to subjectively complexioned accounts of more customarily experienced events. But if one is to discover anything objectively valid, one must resign oneself to an arbitrariness which does a certain violence to the subtleties and infinite variabilities of human nature.

The present investigation has concerned itself with dissociability in general and hypnotizability in particular as the best known criterion of dissociability. We wished to determine whether hypnotizability as a trait was correlated with other discoverable manifestations of dissociability; and whether these in turn were correlated with still other dispositions such as extraversion and introversion.

TECHNIQUE OF HYPNOSIS

We desired to develop a technique for hypnosis which might be followed by any experienced operator with the expectation of obtaining objectively valid results; that is, results that would be quantitatively similar to those obtained by other operators under similar conditions.

For this purpose a set of experiments was performed in each of two consecutive years using volunteer members of the class in abnormal psychology as subjects. The 1928 group was composed of thirty men (Harvard) and four women (Radcliffe), and the 1929 group of twenty-two men (Harvard) and seventeen women (Radcliffe). There were thus seventy-three subjects in all.

Since the results of 1929 were essentially comparable with those of 1928, only differing in respect to a greater precision and uniformity between operators, we shall limit ourselves to a description of the improved technique of 1929, indicating in a footnote how the technique of 1928 differed from it.

In 1928 each subject was tested for hypnotizability by three operators, designated as *A*, *B* and *C*, and in 1929 by two operators, *A* and *B*, (H. A. M. and D. W. MacK.) who worked independently.

Each operator initiated a third or a half of the group (depending upon whether there were three or two operators) to the hypnotic test. In each case a short introductory talk was given to make certain as to the coöperativeness of the subject, to assure him of the innocuousness of the proceeding and to direct him towards an attitude of passivity. The test was carried out in a slightly darkened consultation room without a witness.

As deep a state of hypnosis as possible was induced on the first trial and within two days each subject returned for a second trial with the same operator. This was considered advisable in view of the apprehension that is frequently attendant upon a person's first experience with hypnosis. The markings on the second trial, however, rarely differed from those on the first, and we now believe that the double test was unnecessary. After the two trials with one operator the subject was given one trial with each of the other operators at intervals of a day or more.

To obtain hypnotic suggestibility the subject was directed to lie on a couch with head slightly elevated and eyes focussed upon the head of a pin stuck in the opposite wall. The usual procedure for inducing relaxation, drowsiness and sleep (i.e. statements in a subdued, monotonous voice accompanied by pressure on the forehead and stroking) was employed for about five or six minutes before the specific suggestions to measure the degree of hypnosis were given.

HYPNOTIC INDEX

Hypnosis, it is conceded, may vary as to depth, but there is no general agreement in regard to the number or character of the stages (degrees of depth). Some experimenters have found it convenient to define three stages, others six, others nine. The tendency has been to make artificial distinctions that were not easily identifiable by other experimenters.

With the intention of finding and settling upon a pragmatically suitable formula, we selected suggestibility and amnesia as the chief criteria of hypnosis and adopted the following method for scoring:

Suggestion

After the subject had become thoroughly relaxed on the couch and his eyes closed in the guise of sleep, the following suggestions were given: (i) you cannot open your eyes; (ii) you cannot raise your arm from the couch; and after straightening the subject's arm in a vertical position, (iii) you cannot bend your arm; and after interlocking the fingers of both hands, (iv) you cannot separate your fingers; and finally (v) you cannot speak your name. Before waking the subject, amnesia was suggested.

o = No suggestions carried out. No tendency at all for them to be carried out.

1 = No suggestions carried out, but clear evidence of a difficulty or hesitancy in surmounting them.
1.5 = One suggestion carried out.
2 = Two or three suggestions carried out.
2.5 = Four suggestions carried out.
3 = All suggestions carried out.

Amnesia

0 = No loss of memory and no difficulty in recall.
0.5 = Difficulty in recall, cloudiness, but final memory.
1 = Partial loss of memory.
2 = Complete or almost complete loss of memory.

As a measure of hypnotizability (Hypnotic Index), the ratings for suggestibility and amnesia were added together for each subject. Consequently the hypnotic index might vary from 0 (no hypnotizability) to 5 (complete hypnotizability).*

After the termination of each test introspections were collected, and after the series of tests were complete each subject was asked to mark himself as to hypnotizability with each operator in terms of the formula used by the operators.

It was agreed before the experiments commenced that if an operator considered that one of his subjects was consciously uncoöperative he was to proceed as usual, but that the case was to be excluded from the final tabulations. The reason for this was that we wished to measure hypnotizability and not rapport. In any test whatsoever the coöperating attentiveness of a subject is essential. In the case of hypnosis it is a subtle matter but uncoöperativeness may usually be detected in the initial stages. In 1928 four cases were excluded on these grounds, and in 1929 none.

---

* In 1928 the technique differed in the following respects: (a) under suggestion, the markings 1.5 and 2.5 were not used, and the marking 2 read: "Some, but not all suggestions effective"; (b) the suggestion: "You cannot separate your fingers" was not employed; (c) under amnesia, the marking 0.5 was not used; (d) no special effort was made to secure uniformity of technique for the induction of hypnotic sleep. One operator limited himself to ten minutes, whereas another persisted for forty minutes or more in some cases. In 1929 better results were obtained by agreeing upon a more or less definite procedure which lasted in each case about fifteen minutes.

RESULTS OF HYPNOTIC TEST

The ratings for the hypnotic test (hypnotic indices) as determined by averaging the results of the three operators in 1928 and the two operators in 1929 are given in Table 1.

TABLE 1

The Distribution of the Hypnotic Index

H. I.	NUMBER OF SUBJECTS				Total
	1928		1929		
	Men	Women	Men	Women	
4-5	5	2	3	3	13
3-3.9	6	0	11	4	21
2-2.9	5	0	2	4	11
1-1.9	9	1	3	3	16
0-0.9	5	1	3	3	12
Total	30	4	22	17	73

Examination of this table will reveal that there is a more or less uniform distribution of scores over the entire range. This is not what is to be expected in the measurement of a trait, for a normal distribution is characterized by a definite aggregation in the midzone. Perhaps the method of grouping shown in Table 2 is more valid.

TABLE 2

CLASSIFICATION	H. I.	NO. OF CASES	PER CENT OF CASES
Suggestibility with amnesia	3.6-5.0	18	25%
Suggestibility without amnesia	1.1-3.5	34	46%
No suggestibility	0-1.0	21	29%

The tests show no significant sex differences:

Average hypnotic index

1928	women	2.8 (4 cases)
	men	2.2
1929	women	2.4
	men	2.6

To estimate the value of the method as an objective index for some potential psychological state existent in the subject we must compare

the scorings given by the different operators. In 1928 the coefficient of correlation * between the scores of operators *A* and *B* was .80; of *A* and *C* .63; of *B* and *C* .73. In 1929 the correlation between the scores of *A* and *B* was .81. The average correlation between operators was then .74; or somewhat higher by the improved technique. With the average score of the operators as standard, what is the average deviation of each operator for each case? In 1928 it was 0.54; and in 1929 it was 0.32. This improvement is, we believe, a measure of the increased precision of our technique. Under the present procedure, then, the average error of each operator is about 6.4 per cent. In but one of the thirty-nine cases was there a discrepancy of more than 1.5 points between the scores of the two operators.

Comparison of the objective and subjective scores shows a somewhat surprising uniformity. The coefficients of correlation between the operators' and the subjects' scores were as follows: In 1928 for operator A, .92; for operator B, .82; and for operator C, .83. In 1929 for operator A, .94 and for operator B, .94. The average of these correlations is .89. In 1928 the average difference between the subjects' and the operators' score was 0.58; in 1929 it was 0.28. Of those subjects who disagreed with the operators' scores sixty per cent rated themselves lower than did the operators and forty per cent higher. This shows a slight tendency for the operators to overrate their achievements or for the subjects to underrate their hypnotizability.

Thirteen of the 1928 group of subjects were re-hypnotized by the same operators about five months later. The correlation between the average scores in the fall and in the spring was 0.73. This is about the figure that one would expect for a psychological test after such an interval. In this case it would have been higher if a more objective, and hence suggestibly unreceptive, attitude had not been engendered by a scientific study of hypnosis during the intervening period.

A correlation of approximately + .75, then, is what one may expect between two performances of this test as executed by different men or as done by the same man when several months intervene between performances.

The results of these experiments seem to indicate that our procedure

* All the correlation coefficients reported in this paper were obtained by use of the product-moment formula of Pearson; except in a few instances in which Spearman's foot rule method was employed. Coefficients obtained by this latter formula will be designated by the letter *f* in parentheses (*f*) after the number.

falls within the category of tests having objective validity and consequently the hypnotic index may be used as a convenient objectively verifiable measure of a trait which may be designated as hypnotizability. Our figures show that according to the conditions of the technique twenty-five per cent of a sample college group are hypnotizable to the extent of complete suggestibility with some amnesia.

For purposes of comparison with other traits in a series of experiments performed during the academic year 1928-29, we selected those cases with hypnotic indices of 3.0 or over. Henceforth in this paper we shall refer to these subjects as the H-group. The subjects that scored 1.0 or below, we shall designate as the non-H-group.

HYPNOSIS UNDER OTHER CONDITIONS

(*a*) *Group hypnosis.* Following the practice of Wells,[23] one attempt to hypnotize a class of some fifty students was made in 1929. Instructions and suggestions were given very much as in the test for obtaining the hypnotic index, but in this case each subject was sitting relaxed in his seat. The suggestions given were: (1) you cannot lift your feet off the floor, and, after the fingers of the two hands had been interlocked, (2) you cannot separate your hands. No attempt was made to produce amnesia. The coefficient of correlation between the scores in this test and the hypnotic indices was $.52 \pm .08$.

(*b*) *Hypnotic and waking suggestibility as measured by the Hull Technique.*[7] In a further attempt to determine the relationship between the hypnotic index and suggestibility under other conditions, a series of experiments which lent themselves to a more precise quantitative treatment was conducted. (H. B. and D. W. MacK.)

Technique

Upon arrival in the experimental room the subject was asked to read the following instructions.

> You are going to take part in an experiment involving various psychological factors which have rather important implications from a theoretical standpoint. You will be blindfolded throughout the course of the experiment. It is important that you adopt a perfectly natural attitude during the course of the experiment in so far as you are able. In other words, try to behave just as you would in any situation outside the psychological laboratory, except when you are told to adopt some other specific attitude.
>
> The only stimuli that will be presented will be words spoken in a natural tone of voice.

The eyes of the subject were then covered with tight fitting goggles, the lenses of which had been painted black to make a perfect blindfold. After which

he was moved by the two experimenters in a purposely awkward manner so that he was standing about four feet from a high table on which was placed the Hull apparatus. As the subject was being moved into position one of the experimenters clipped the thread of the apparatus to the back of the subject's coat collar by means of a paper clip. No subject was aware of this attachment being made—the awkward handling having directed his attention to the general movement of his body.

The Hull apparatus has been described in detail elsewhere.[1] In brief the set-up is such that the thread attached to the subject's collar runs back about four feet and several times around a flanged aluminum pulley. This pulley has a smaller flange, one third the diameter of the outer flange, around which another thread is wound several times. At the end of the brass rod is attached a stylus, and a light torsion spring to keep the stylus bearing with a constant pressure on the smoked paper of a kymograph drum. In this way any movement on the part of the subject is recorded on the kymograph paper on a vertically oscillating line, the excursion of the line being one third of the movement made by the subject.

The waking suggestions which were given were that the subject was either falling forwards or backwards. But since no one is able to stand perfectly motionless while blindfolded, and since subjects vary greatly in the extent to which they sway, it was necessary to obtain a measure of the normal sway of each subject. Accordingly the first record taken was a normal record, the directions being:

> "I'd like you to stand right here, please. Stand in a comfortable position with your feet apart. You will stand there for about a minute. All right, we'll begin now."

A minute record was then taken.

After a few minutes rest the subject was asked to daydream. The directions were:

> "For the next few minutes, allow yourself to daydream. Just give yourself up to any pleasant phantasy, allowing your mind to go off into a state of dreamy reverie."

The suggestions given after one minute, to allow the subject to have his reverie well started, were spoken in a very soft voice by the experimenter, who was standing about ten feet away. The suggestions were as follows:

> "You're falling forward, you're falling forward, you're falling forward, you're falling forward. Falling. Falling forward, falling forward, falling forward, falling forward. You're falling forward. Falling. Falling. Falling forward. Further forward. Further forward. Falling forward. Further. Falling forward."

After a further few minutes rest the subject was asked to assume his natural attitude. The directions given were:

> "I'd like you to stand right here, please, again. Stand in a comfortable position with your feet apart. I do not want you to daydream as you did this last time, but rather assume your natural attitude as though you were not in the laboratory, but outside. You will stand there for about two minutes, and if you're ready we'll begin now."

After a lapse of ten seconds the kymograph was started and the following suggestions were given by the experimenter in his natural tone of voice as he stood beside the subject.

"You're falling forward. You're falling forward. You're falling further forward. Further forward." Etc., as before.

After a further rest of a few minutes the final record was taken, the suggestions being given while the subject was in a state of relaxation. The instructions were:

"I'd like you to stand right here, please. Stand in a comfortable position with your feet apart. Relax all over so that your whole body feels dull and heavy. Perfectly relaxed. Relaxed all over. (Lift arm and let it drop to be sure relaxation has taken place.) Relax mentally, too. Just forget all that you've been thinking about before coming in here, and now just think of complete muscular and mental relaxation. Be just as passive as possible and listen to everything that I say. Don't resist what I say and on the other hand don't try to consciously or voluntarily carry out what I say; but rather just attend to everything and accept in a passive, completely relaxed and uncritical manner everything that I say. All right, if you are completely relaxed we'll begin now."

After a lapse of ten seconds the kymograph was started and the following suggestions were spoken very softly by the experimenter who stood about ten feet from the subject.

1. "You are going to sway forward. You are swaying forward now. You can't help yourself. You are swaying forward. Further forward. Forward. Forward. Swaying more. Further yet. Further yet. You are leaning forward still more. More. More yet. More yet. Still more. Further forward. There you go further forward. Swaying forward more. More still, leaning further still. Further forward."

2. "Now you're going to sway backward. You're going to return to your original position. You're swaying backward. Back more. More. Back more yet. Back to your original position. You are swaying back. Back. Further still. Swaying more. Still more. Back further yet. Way back now. You're swaying way back. Way back. More still. Further back. Further. Further. Back more. Still more. Way back now."

In this way four records were obtained of the extent of body sway under four different conditions:

1. Normal state with no suggestions.
2. Suggestions in daydream state.
3. Suggestions in normal state.
4. Suggestions in relaxed state.

A measure of suggestibility under the three different conditions was obtained in the following way. On the records the extent of variation in movement, that is, the distance from the lowest point on the curve to the highest point, was measured vertically in terms of ⅛ of an

inch. On the first record this measurement gave an index of each subject's normal mobility. The value thus obtained for each subject was then subtracted from the value obtained for each subject in the other three records, thus giving indices of suggestibility in the daydream state, the normal state, and the relaxed state.

An inspection of the records at once reveals the fact that suggestibility is not the same under the three conditions. Whereas a subject may sway forward to the limit, even breaking the thread, in the relaxed state, the same subject may sway practically not at all in the normal attitude state.

This is further shown when the scores of the subjects under the different conditions are intercorrelated.

Suggestibility in		Suggestibility in	r
Daydream state	*with*	Relaxed state	$.65 \pm .087$
Daydream state	*with*	Normal state	$.48 \pm .11$
Relaxed state	*with*	Normal state	$.42 \pm .12$

These figures would seem to indicate that there are subtle differences in a subject's suggestibility which are dependent upon the physical and mental condition or attitude of the subject. They further indicate that the state of daydream and the state of relaxation are more alike in respect to their conduciveness to suggestion than are any other two states. This is what we would theoretically expect to be the case.

To determine the relationship between hypnotizability (H. I.) and suggestibility under the three investigated conditions the following intercorrelations were worked out:

	r
Hypnotizability *with* Suggestibility in the Relaxed state	$.52 \pm .12$
Hypnotizability *with* Suggestibility in the Daydream state	$.23 \pm .16$
Hypnotizability *with* Suggestibility in the Normal Attitude state	$-.06 \pm .17$

The correlation here between hypnotizability and suggestibility in the relaxed state is significant and is in agreement with the correlation of $.52 \pm .08$ which was obtained between the hypnotic indices and the scores in group hypnosis. In both cases the attitudes assumed were very much like that established in the standard hypnotic test.

We have seen that the standard hypnotic test correlates with itself about $+.75$. Now we discover that the correlation with hypnosis as measured by the group test and the swaying test is approximately $+.52$. These low figures should warn us that when we come to correlate hypnosis with other traits different from hypnosis but expressive of

a similar underlying disposition we should not discard results that give us a correlation of over +.30.

The correlation between hypnotizability and suggestibility in the daydream state is positive but hardly significant. The reason for this may well be that the daydream state was rarely obtained. At least, many subjects reported that they were not able to lose themselves in reverie. Standing blindfolded in a psychological laboratory is not, to be sure, the most auspicious condition for unleashing phantasies. The correlation between hypnotizability and suggestibility in the normal attitude state is $-.06 \pm .17$. This fits in with other results to be discussed later.

THE NATURE OF HYPNOSIS

In the interpretation of psychological phenomena from the standpoint of personality differences, we have been accustomed to expect two complementary forms of explanation: (1) the finalistic, and (2) the aptitudinal. The finalistic description explains individual differences in terms of the varying intensity of particular needs (cf. instincts, desires, predominant tendencies); whereas the aptitudinal description accounts for these differences in terms of varying degrees of specific abilities (cf. capacities, skills, functional efficiencies). A man may become a painter because he has a great admiration for the old masters, or because he has a natural aptitude for the perception of color values. And so we see many persons struggling unsuccessfully yet valiantly at vocations for which they are not fitted, as well as persons of talent who, because of a lack of desire, never achieve excellence.

Applying this reasoning to the matter at hand, hypnotizability, we might say that a person is hypnotizable because he wants to be (consciously or unconsciously) or because he has the capacity to be; and the degree to which he is hypnotizable is a measure of his need or his aptitude or both.

In this section let us consider the question of what needs of the subject are fulfilled in the hypnotic experience. Two hypotheses have been advanced to account for hypnotizability on this basis: namely, (1) the need for submission (McDougall)[19] and (2) the need for sex (Freud).[8] The need for submission (cf. masochism) includes the desire for guidance and the passion for worship and sacrifice. If this need were the determining factor in the hypnotic situation we should expect to find variations in the same individual correlative with variations in the degree of self-assertion and prestige of different operators;

and to account for individual differences with the same operator, variations in the intensity of this need in different subjects.

(*a*) *The prestige and personality of the operator* has been variously estimated by different authorities. The public, learned in the tradition of Mesmer and the professional vaudeville hypnotist, have very generally believed in the irresistible force of a Rasputinish personality with magnetic eyes; and the Nancy School, it seems, were not unfavorable to this view. Among those who have stressed the importance of the operator may be mentioned Krafft-Ebing, Schrenk-Notzing, and Forel.[1]

Our own experiments were not planned to provide a conclusive answer to this question. If this had been our object we should have selected operators with unequivocal individual differences as to age, reputation, assertiveness and so forth. It is true that there was a difference in rank: an assistant professor (A), an instructor (B), and an assistant (C), and that the first of these gave the lectures in the course; but in other respects, age, height, weight, reputation, and self-assertiveness, there were no marked differences and the setting for all the experiments was the same. That no variations due to the rank of the operators occurred is shown by averaging for each operator the objective and subjective scores for all subjects and comparing the total figure with faculty rank. In 1928 the average score of 28 subjects for A was 2.195; for B was 2.075; and for C was 2.285. In 1929, the average score of 39 subjects for A was 2.535, and for B was 2.520.

The rather extraordinary consistency in the results obtained by the three operators, however, does not suggest that the personality of the operator is an important factor in the degree of hypnosis induced. Our past experience under the guidance of Dr. Morton Prince has given us a similar impression. Once the coöperation of the subject (rapport) is obtained it seems to make little difference who is the operator. It has repeatedly occurred that subjects with high hypnotic indices as measured in the clinic were also found to be hypnotizable when coöperating with their classmates outside the clinic. We recall such cases as that of a young lady who was easily hypnotized by her younger sister seventeen years of age. Not infrequently a fellow undergraduate will have even better success than an instructor. For instance the only subject who had submitted to hypnosis before these experiments took place claimed that he had been successfully hypnotized by his roommate, whereas in our hands he proved to be practically unhypnotizable. These facts and reflections, then, lead us to suppose that granting a certain level of skill

and confidence on the part of the operator, except in an occasional refractory case, no further manifestations of skill or power have any effect.

(*b*) ***Individual differences in the need for submission.*** To prove the importance of the submissive instinct—a suggestion of McDougall's—it should be shown that the intensity of the submissive or masochistic component in the personality of the subject is positively correlated with the hypnotic index. This is of course very hard to demonstrate without an extended psychological analysis of each case. It is not easy to tell in some cases whether an assertive attitude is or is not cloaking an unconscious tendency to submission. We have, however, some data that bear lightly on this point.

In our initial tests it was noticed that the average height and the average weight of the H-group (68.8 inches and 142 lbs. respectively) were less than the height and weight of the non-H-group (70.5 inches and 152 lbs. respectively). This fact seemed to suggest an elementary physical inferiority, and hence perhaps submissiveness, which might account for some cases. Later experiments, however, proved this to be a false lead. For instance, a tall rugged man, the only Varsity football player in the class, was discovered to have the highest H. I. in the entire group.

Another false lead, which seemed to be supported by impressions gained from past experience, was the notion that hypnotizability was proportionately higher among Jews than among Gentiles. Our results in 1928 seemed to corroborate this, for we then found that of the total number of Jews in the two groups 83 per cent were in the H-group (H. I. 3 or above) and 17 per cent were in the non-H-group (H. I. 1 or below); whereas of the total number of Gentiles in the two groups 55 per cent were in the H-group and 45 per cent in the non-H-group. This finding might be said to hint at the rôle-dominance of the submissive instinct in hypnosis, since its presence in the personality of the Jew—often unconscious, and compensated for by a powerful development of superiority trends—is a matter of common observation (cf. Ludwig Lewisohn's "The Island Within"). However, our 1929 experiments with a larger number of subjects did not confirm this point, for we now found that a larger percentage of Gentiles than of Jews were hypnotizable. Of the total number of Jews in the two groups 67 per cent were in the H-group and 33 per cent were in the non-H-group, whereas of the total number of Gentiles in the two groups 77 per cent were in the H-group and 23 per cent were in the non-H-group.

One of us (H. A. M.) recalls a patient suffering from intense anxiety associated with certain self-corrective compulsions who, on her first visit, asked earnestly to be hypnotized. On analysis, she was found to have a very active need for submission, with incessant assault phantasies. Needless to say she developed a rather extreme positive transference for her physician. Despite all this she was found on two occasions, after the analysis had progressed for several months, to be unhypnotizable. In her case the will seemed to be there but not the aptitude. Other similar cases have formed part of our experience.

Two objective tests which bore upon different aspects of submission were presented to the class with negative results.

A modification of H. T. Moore's test [18] for measuring suggestibility to group opinion (collectivism) was devised by one of us (H. B.). This test was found to be effective to a large extent outside the consciousness of the subject, and hence might be expected to activate a latent or unconscious need for submission if present.

It was discovered (study to be reported elsewhere) that the attitude of the subjects who scored low in this test was manifested by non-submissive, negativistic forms of behavior, which were carefully observed and recorded during the course of a half-term period. S (group suggestibility) and H. I. (hypnotic suggestibility), however, were only correlated to a small extent (+.22), and among the subjects that showed themselves to be the most negativistic, anti-collectivistic, or in other words non-submissive, both in the test and in overt behavior, there were found some of our most hypnotizable subjects. In 1929 this test was repeated, and this time there was no correlation whatever with the hypnotic index (—.05). This negative result indicates what other tests will confirm, namely, that there are many forms of suggestibility which have no psychological relationship to one another.

Another test which purports to give a measure of assertiveness is the Allport ascendance-submission reaction study.[1] It was designed to expose the customary behavior of a person in situations which give an opportunity for the objectification of assertive or submissive traits. This test was administered to a number of our subjects but no correlation was found between it and the hypnotic index.

Our data then, such as they are, lead us to conclude that the need for submission, although of crucial contributing significance in some cases, perhaps, is not the chief determining factor in hypnotizability.

(*c*) *Need for sex.* The suggestion offered by Freud [8] that hypnosis

is an exaggerated transference phenomenon based on the sex instinct cannot be understood except in a highly metaphorical sense. If this statement were taken literally—and all scientific statements are meant to be taken literally—one would have to conclude that we were in truth measuring degrees of sexual desire by our hypnotic index. We should then have to explain why there were no sex differences in H. I.; and investigate whether there were not indications of an overactive homosexual component in our male subjects with high indices. Manifestations suggestive of homosexual tendencies were no more common among the H-group than among the non-H-group as far as we could judge.

If the word sex is taken in a more general sense, as Freud himself occasionally uses it, to stand for gregarious and social inclinations, the notion might be advanced that hypnotizability is a measure of the herd instinct (need for association) in our subjects; an idea which would coincide with the theory that places hysteria and hypnotizability in the extravert category. We attempted to put this hypothesis to the test. It was not simple, since the concept of extraversion includes, we believe, a number of distinct psychological items. Nevertheless the operators A and B settled upon a list of characteristics which they were to use in assigning ranks to the subjects on an introvert-extravert scale. These ratings, independently arrived at, showed a surprising agreement. To obtain a subjective judgment of the matter the 1929 group was given the Neymann-Kohlstedt [20] questionnaire for introversion-extraversion. The coefficient of correlation between the average scores of the two operators and the scores on the questionnaire was .58. As this is a significant figure, the rank order obtained by combining the results of these two methods of rating (objective and subjective) was accepted as the measure of relative introversion-extraversion in the group. When this rank order, however, was correlated with the rank order for hypnotic indices, no significant coefficient was obtained. We found, in fact, that a number of extreme introverts, one of them with the earmarks of schizophrenia, were easily hypnotizable.

Although our attempts to discover a finalistic or dynamic explanation of hypnosis in terms of needs have been unsuccessful, it must be pointed out that our experiments were not arranged so as to throw such a need, if present, into relief. We used only subjects who were willing to be hypnotized, a willingness which we took to rest upon their coöperativeness (need for association; herd or gregarious instinct) and to some extent upon their scientific interest (need for cognizance; curi-

osity). We do not consider that we have fully explored the need for submission, and we have not investigated systematically a need which we feel, in some cases at least, may play an important rôle, namely, the need for attention (self-display instinct; exhibitionism).

For the present, however, in view of these negative findings we may abandon the finalistic in favor of the aptitudinal form of description.

Before leaving the subject, however, we should like to suggest that a distinction be made between rapport and hypnosis. From theoretical considerations it would seem probable that the prestige of the operator, the submissive instinct and perhaps erotic fixation would play a part in the establishment of rapport, but our experiments lead us to believe that once the full coöperation of the subject has been obtained the aptitude, or in other words the psychological constitution, of the subject in respect to its dissociability becomes the chief factor which determines whether hypnotic sleep is to be induced.

An incident which demonstrated the importance of rapport as a prelude to hypnosis was furnished by one subject who, before the commencement of the experiments, had chosen operator C to consult about some intimate personal problems. Before the hypnotic session with operator A, this subject expressed the hope that during the hypnosis he, the subject, would not reveal to A any of his secrets. He asked A furthermore, in case he did reveal anything, to promise never to disclose it. With this anxiety uppermost in his mind he proved to be unhypnotizable (H. I. 0.), but in the hands of C, to whom he had given his confidence, his H. I. was 3.

These tests and theoretical considerations lead us to an examination of Janet's psychological constitution concept as a suitable explanation of hypnotizability. To Janet there was no difference between the constitution of the hysteric and that of the hypnotic subject. In both cases there was the psychological disposition (potentiality) or aptitude for the circumscription or narrowing of focal consciousness with the elimination from awareness of other functioning psychical processes. It was such a condition which allowed for the vivid, uncritical objectification of psychical elements (cf. sensory presentations) as pseudophysical facts. This somewhat perplexing state of affairs was attributed to dissociation, since it was dissociation which brought about the narrowing of consciousness as well as the vivid hallucinatory character of psychical experience.

A COMPARISON OF HYPNOTIZABILITY WITH OTHER MANIFESTATIONS OF DISSOCIABILITY

(*a*) *Hysteria*

Our experiments prove that hypnotizability is a personality trait and not merely a symptom of hysteria. Experience has taught us, moreover, that hypnosis is not always successful during an attack of hysteria. We recall three recent cases: a little girl of twelve years with recurrent attacks of mutism, a young woman of twenty years with post-operative paraplegia, and an older woman with a coarse tremor of an hysterical type, none of whom were hypnotizable. It is probable that unconscious resistance to hypnosis functions in hysteria in the same fashion as resistance to free-association occurs during an analysis.

A great deal of evidence has been accumulated, however, which though not of a statistical character indicates that hypnotizability and hysteria are related. The implication is that a person who has or has had hysteria will be hypnotizable, and that a hypnotizable subject who becomes neurotic will develop symptoms of a hysterical character. Numerous investigations of Prince and others would seem to mark this as a probable hypothesis. Our studies add only a modicum of positive evidence, for in these experiments we were dealing with a normal college group with little symptomatology.

There was only one instance of hysteria among our subjects. This was the case of a man with an H. I. of 4.7 who gave a history of fugue at the age of sixteen years. Two subjects acknowledged frank compulsions. One of them with an H. I. of 1.8 indulged in various self-corrective acts, repeatedly turning off the gas at night and so forth. The other complained of contamination anxieties and hand-washing compulsions. His H. I. was 1.0. These three cases support the hypothesis that a high H. I. occurs in hysteria, and a low H. I. in the obsessive-compulsion group. In 1929, however, three subjects with hypnotic indices above 3 reported trivial compulsions, most of which had been outgrown. But since such mild temporary fixations are not uncommon in hysteria, these findings do not give us a basis for differentiation.

(*b*) *Manifestations of dissociability in naive experience*

Janet studied dissociation in its exaggerated forms as found in bona fide cases of hysteria. And then from these studies he developed theories to explain the type of process characteristic of the mental

life of hysteria. Now if the present widely accepted generalization which explains hypnosis by reference to dissociation is correct, it should be possible to discover in hypnotizable subjects characteristics of mental functioning which could be attributed to mild degrees of dissociability. A little speculation at this point will do us no harm.

We can conceive of dissociation as occurring both in space and in time. By the former, dissociation in space, we refer to a partial or complete disjunction within the organization of the psyche, so that two synchronous psychological processes—one of them insulated from consciousness—occur without interaction or functional discord (cf. automatic writing, anaesthesias, mutisms, and so forth). Dissociation of this kind occurring to a mild degree in normal people might be divided on theoretical grounds—and it seems to us that observation supports the thesis—into two types, one in which attention was inwardly directed upon trance-like phantasies, and the other in which it was focussed outwardly upon the presentational immediacy of the sensational world. In the former instance the subject would appear abstracted, since the psychological processes that related him to the external world were temporarily dissociated from the focus of consciousness; whereas in the latter instance it would be the usual inner processes, memories, hindthoughts, self-criticisms, and rational considerations which would be dissociated as the subject lost himself in the vividness of the concrete momentary happening.

With the term, dissociation in time, we should describe the history of mental events when they occurred as a series of discrete moments or episodes insubstantially related to one another. We might call this psychological atomism. When these moments were dominated by inner processes, we should expect episodes to occur which appeared quite out of keeping with any tangible objective situation (cf. fugues, somnambulisms). But when the personality was in rapport with external happenings, it would bear a chameleonic aspect. In consequence, a characteristic feature of the hypnotizable personality would be its atomic mobility; its capacity to move from one moment of experience to another without delay. Behavior would be characterized by a lack of determining general principles. It would give others an impression of discontinuity and inconsistency. In the realm of cognition this disposition would manifest itself as distractability with a lack of logical continuity and relatedness of thought. The exact opposite of this is true for the obsessive with his tendency to connect everything by

massive generalizations and rationalizations. It was this quality which led Janet to amuse himself by suggesting that philosophy was a species of psychasthenic compulsion.

Questionnaire. In numerous hypnotizable subjects these suppositions relating to the dissociable personality have been confirmed by observation, but there have been exceptions that have puzzled us. Obviously there was need for a more systematic investigation of the subject. And so, as a beginning, an attempt was made to get at the subjective aspect of these phenomena by devising a questionnaire centred about the principal mental characteristics of the hysteric as outlined above. It proved unsatisfactory. It was very difficult to word the questions intelligibly, and even when their meaning was unequivocal the self-insight of the average subject was hardly sufficient to enable him to answer them. A few of the questions were found to correlate rather consistently with the H group (H. I. 3 or above). We have no assurance that there was anything more than a chance correlation here, but we present them as indicators.

The subjects were asked to answer the questions Yes or No, and to estimate in each case the frequency or intensity of their reactions on a 0 to 5 basis. Thus the scale varied from No 5 to Yes 5. The subjects were asked to mark themselves not according to their desires, but on the basis of a careful recollection of their actual experience in the past.

The following questions in the order named were found to be the most effective in differentiating the H-group from the non-H-group. The answer (Yes or No) given after the question is the theoretical H tendency. In parentheses are given the average H answers and the average Non-H answers in degrees.

It was found in many instances that the H-group taken as a whole gave the opposite answer to that which was to be expected. (cf. Questions 1, 2, 5, 7 and 11.) In such cases, however, the differences in the H-group and the non-H-group were manifested by the degree of certainty with which the questions were marked Yes or No.

Question 1. Do your daydreams ever become so vivid as to take on the aspect of reality?

Answer: Yes (H: No 0.5; Non-H: No 3.4)

Question 2. Are there many episodes in your life which now seem unreal, as though they happened to another person?

Answer: Yes (H: No 0.7; Non-H: No 3.3)

Question 3. Do you feel that you are a very different kind of person on some occasions than you are on others?

Answer: Yes (H: Yes 2.1; Non-H: No 0.4)

Question 4. Do you habitually try to connect everything that happens with your past experience as well as with the future?

Answer: No (H: No 0.4; Non-H: Yes 1.7)

Question 5. Did you, as a child, do much walking in your sleep?

Answer: Yes (H: No 2.4; Non-H: No 4.4)

Question 6. Do you find it necessary to complete an undertaking you have once started no matter how boring and irksome it has become?

Answer: No (H: No 0.6; Non-H: Yes 1.3)

Question 7. As a child, did you often have tantrums or fits of temper?

Answer: Yes (H: No 0.9; Non-H: No 2.7)

Question 8. Do you find it easy to dismiss mistakes which cannot be rectified?

Answer: Yes (H: Yes 0; Non-H: No 1.3)

Question 9. When reading an interesting book near a window, is your attention apt to be drawn to occurrences outside?

Answer: No (H: No 1.3; Non-H: No 0.3)

Question 10. If you are interrupted for an instant while at work, can you quickly resume your train of thought?

Answer: Yes (H: Yes 3.4; Non-H: Yes 2.7)

Question 11. Do you usually look for the best ultimate decision rather than for the simplest one which will answer the purpose?

Answer: No (H: Yes 1.9; Non-H: Yes 2.7)

The questions in this questionnaire were interspersed amidst other questions of an entirely different kind so that the nature of the psychological problem under investigation was less obvious to the subjects.

We publish this questionnaire to show what questions were correlated with the H-group, and therefore to serve as a hint for elaborating a much more adequate questionnaire or at least a set of questions the answers to which might be obtained in private interviews.

(c) *Dissociability of function in test performances*

Two attempts were made to investigate dissociability systematically in respect to its possible bearing upon functional effectiveness when subjects were required to perform two tasks simultaneously. Neither of these investigations yielded positive results. The first of them we shall dismiss with a paragraph, but the second, we believe, is interesting enough to report in some detail.

(i) *Dissociated audition test*

Certain preliminary tests done by one of us (D. W. MacK.) led us to believe that in some persons the perception of barely audible sounds was more acute when the subjects were relaxed and absorbed in reverie than when they were listening with concentrated attention. Since the response to the hearing of a sound was given by pressing a finger key it was possible that the ear-finger system became partially dissociated from consciousness and in consequence functioned more effectively. The capacity so to dissociate during reverie would be the determining factor according to our hypothesis if an increased acuity of audition occurred. When the matter was systematically investigated, however, by determining the auditory limen for each subject under the conditions of concentrated attention and relaxed reverie, no correspondence was found between the variations in audition and hypnotizability. The chief difficulty was to engender a satisfactory state of phantasy. Despite the aid of an illuminated screen in a dark room, phantasies could not be produced to order. The results for each subject were so variable, moreover, that whatever relationship with dissociability might have existed, it was completely obscured by other factors.

(ii) *Dual task test*

One of us (D. W. MacK.) devised a series of experiments to measure the efficiency of an individual in performing (1) two simple tasks separately, each in one unit of time, and (2) the same two simple tasks simultaneously in one unit of time, the difference in total efficiency in the two tests to serve as a measure of the subject's relative ability to cope with two tasks at once.

The theoretical considerations that led to this experiment were as follows: The simultaneous performance of two tasks which require cognition calls presumably for either (a) a rapid alternation of attention (consciousness) from one task to another, or (b) a partial disso-

ciation of consciousness, so that the two tasks may proceed synchronously with little mutual interference. It was the opinion of many of the investigators of hypnotic phenomena, notably Morton Prince and Janet, that under the conditions of a dissociated consciousness (cf. the extraconscious solution of mathematical problems as a post-hypnotic process) the latter of these two possibilities occurred. They believed that two cognitive processes could proceed synchronously without interference, one of them being unconscious to the other. The quantitatively controlled experiments of Messerschmidt,[17] however, showed that at least in tasks that demanded application, such as reading and arithmetic, an alternation of attention seemed to occur even when one task was being performed as a post-hypnotic act by a dissociated integrate of which the waking conscious was unaware. The total efficiency of the two processes when the attempt was made to carry them on more or less simultaneously was less than it was when half the time was devoted to each process in turn.

It might seem that the loss of efficiency could be explained by a distribution of cognitive energy, if we may use such a term, between the conscious and the unconscious mental events, so that each one of them proceeded, let us say, at half speed but without conflict or interference one with another. This was probably not the case, however, as there were obvious signs of conflict, for instance the acceleration of one process—reading by the conscious integrate—caused a retardation or cessation of the other process—writing (automatic) by the unconscious integrate—and vice versa.

In the case of other tasks, however, involving different psychological systems, and particularly when one of them is of a simpler nature not demanding cognition, everyday experience informs us that they may be performed synchronously with readiness and precision (cf. talking or directed thinking when one is walking, eating, driving a car, and so forth). We may recall, for instance, Nietzsche's advocacy of uphill walking because of its favorable effect upon creative thought.

At this point we should like to speak of tasks that demand the concentrated attention of the subject for their performance and tasks that do not. We propose to call such tasks cognifactive and non-cognifactive respectively.

A cognifactive task, then, is one, the meeting or solution of which calls for concentrated attention (conjunctive cognitive process). As a rule it presents a situation which is novel, exigent, and interest-provok-

ing; which requires speed and accuracy of directed, relevant, and adaptive cognition; which claims a fully-integrated consciousness and perhaps a logical or creative mental event for its elucidation. It may be an occurrence which calls for a tangible relation with the objects of the external world or it may be an intellectual problem which the mind is bent upon solving.

A task that is not cognifactive is one that does not require concentrated attention, that can be performed automatically, leaving consciousness free and relaxed (disjunctive) or preoccupied (conjunctive) with other things.

Of course no task is inherently cognifactive by itself. For a child learning to talk or an adult learning a foreign language or a poet searching for the *mot juste,* mere language becomes a cognifactive task. But for the man who cares naught for qualitative precision in words, speaking the vernacular is a non-cognifactive task. Cognifaction, then, is as much a function of the individual as it is of the task. Learning and experience tend to move any particular task or class of tasks from the cognifactive to the non-cognifactive category. Cognifaction obviously refers to the extent to which the so-called higher mental functions are involved. It might, for instance, be used to apply to constructively intelligent behavior as opposed to instinctive behavior.

Since cognifaction implies mental absorption, and hence an interference or inhibition of other irrelevant images and relations, one might measure the degree of cognifaction required for the performance of any task by determining the amount of mutual interference that occurred when a standard task that demanded complete cognifaction was simultaneously presented. The interference might be measured by summing the percentage loss of efficiency in the performance of each task when both were done simultaneously. A cognifaction quotient (c.q.) of 100 per cent would signify complete interference. If the c.q. was over 100 per cent it would indicate that the subject was less efficient when he did the two tasks synchronously than when, by spending a certain proportion of the time on each task, he did them separately.

Now if hypnosis, as it is generally conceded, is a particular form of dissociation, the hypnotic index may be taken as one measure of dissociability, and consequently our H-group might be tentatively considered as the relatively dissociable group. The problem is: how does the capacity or tendency to dissociate affect efficiency in the performance of two synchronous tasks? Messerschmidt compared hypnotizable

subjects working at single and then at double tasks in a state of post-hypnotic dissociation. In these experiments we wished to compare the hypnotizable and the non-hypnotizable groups under double task conditions, that is, conditions which we supposed would tend to produce some degree of functional conflict or dissociation.

With the solution of this problem in view four pairs of simple tests were selected. It was not necessary for our purposes to determine the cognifaction quotient of each separate test, since each pair of tests could be taken as a unit. For instance, if tasks x and y formed a pair, the efficiency of each subject in the performance of x and in the performance of y was separately measured. The tasks were then given simultaneously and the impairment of efficiency in each task was measured. The sum of the percentage loss of efficiency in the execution of each task was taken as the measure of mutual interference and hence the measure of cognifaction by the two tasks taken as a unit (c.q. or cognifaction quotient).

TABLE 3

The Performance Scores of Simple Tasks When Done Separately and When Done in Pairs in Hypnotizable and Non-hypnotizable Subjects

SUBJECT	AVERAGE RANK ORDER IN THE 8 SINGLE TASK TESTS	H	NON H	SUBJECT	AVERAGE COGNIFACTION QUOTIENT IN THE 4 DUAL-TASK TESTS	H	NON H
Fr.	5.7	°		Fr.	39.8	°	
Ha.	6.0			Hu.	45.6	°	
Pi.	6.4	°		Ro.	49.0	°	
Le.	7.7	°		Ka.	54.6		
Ka.	7.9			Lu.	54.8		°
Ro.	8.1	°		Pi.	55.0	°	
Hu.	8.4	°		Ha.	57.6		
An.	8.6			Fi.	60.4	°	
Ca.	8.8	°		Fl.	61.8		
He.	8.9	°		He.	62.0	°	
Wh.	9.0		°	Ca.	62.8	°	
Lu.	10.1		°	Le.	63.6	°	
Fl.	11.6			An.	65.8		
Ros.	11.7		°	Ros.	69.8		°
St.	12.2	°		Wh.	71.6		°
Fi.	12.9	°		Ly.	73.2		°
Ne.	13.4		°	Ne.	84.8		°
Ly.	13.6		°	St.	85.0	°	

TABLE 4

Performance in the Dual-task Test

		1 AVERAGE COGNIFACTION QUOTIENT FOR ALL SUBJECTS	2 STANDARD DEVIATION	3 H. SUBJECTS IN UPPER HALF	4 NON-H. SUBJECTS IN LOWER HALF	5 COEFFICIENTS OF CORRELATION WITH H-I.
		%	±	%	%	
A	Tapping and opposites	16.8	12.4	66	80	.260
B	Needles and reversed clocks	57.2	33.4	56	60	.187
C	Pegs in board and checking nos.	58.2	17.4	44	60	.213
D	Sorting cards and anagrams	115.8	18.6	22	40	—.052

Each dual-task was performed twice, and consequently each figure in the table is the average of two tests.

Column 1 gives the figures obtained by summing the percentage loss of efficiency incurred in each test when both tests were performed simultaneously.

Column 5 gives the average of the two correlation coefficients obtained when the hypnotic indices were correlated with the scores in each of the two performances separately.

Technique *

The eight tests may be briefly described.

(i) Tapping test. The Whipple tapping board with the taps recorded by means of a signal magnet actuating a stylus upon the smoked paper of a kymograph.

(ii) Opposites. A list of words presented in columns, to each of which the subject was directed to respond verbally by giving the exact opposite.

(iii) Pegs in board. Steel pegs to be inserted into holes arranged in orderly columns; the board being covered by a small table so that the subjects would have no visual cues in the performance of the task.

(iv) Checking numbers. A sheet of paper with two columns of figures and to the right of these, two other columns; one headed *Same*, and the other headed *Different*. If both figures on the same line were identical, the sub-

* The kind of tests suitable for our purposes and the general plan of administering the tests were suggested by the work of E. Neil McQueen: The Distribution of Attention. British Journal of Psych. Monograph supplement. Vol. II, 1917-19.

ject made a check in the column headed *Same;* otherwise in the column headed *Different.*

(v) Card-sorting. A box with two compartments; and two well-shuffled packs of cards with backs of the same color but of slightly different design.

(vi) Anagrams. A word presented at the aperture of an exposure screen with the letters of which the subject was to make up as many words as possible.

(vii) Threading needles.

(viii) Reversed clocks. Three figures representing a particular time of day (for example 6:22) were presented in the center of the exposure screen, the subject being required in each instance to announce what time it would be to the nearest minute if the small and the big hands of the clock were to change places. With each announcement a new figure was presented.

In the dual task tests the following tests were combined: A. Tapping and opposites; B. Card-sorting and anagrams; C. Pegs in board and checking numbers; and D. Needles and reversed clocks.

All the tests were done with the experimenter screened. In each group the tests were given both separately and together in all possible orders; and the entire test repeated for each subject after a week's interval.

These tests were done with a group of eighteen volunteer students (seventeen men and one woman). Out of this group nine had an H. I. of 3 or over (H-group) and five had an H. I. of 1 or under (non-H-group). The others were intermediate. By studying the two extreme groups (H and non-H) in relation to the tests certain slight differences become apparent. For instance, if we divide the ranked group in each dual-task test into an upper hyper-efficient class and a lower hypo-efficient class (nine subjects in each class) we may determine the proportion of H subjects and non-H subjects in each class.

When all the tests are taken together (Table 3) it appears that the H subjects tend to range themselves in the hyper-efficient class and the non-H subjects in the hypo-efficient class both in respect to their scores in the eight single task tests and in respect to their scores in the dual task tests. In the single task tests 66 per cent of the H-group are in the upper (hyper-efficient) class. In the dual task tests 56 per cent of the H-group are in the upper class and 80 per cent of the non-H-group in the lower class. The average cognifaction quotient for the H-group is 58.1 per cent; and for the non-H-group is 70.8 per cent. This signifies that there was 12.7 per cent more interference in the non-hypnotizable subjects than in the hypnotizable subjects when the results of all the tests were averaged together.

The correlation of the rank order of hypnotizability with the rank order for the single task tests is .19 (f); and with the rank order for

the dual task tests is .23 (*f*). These figures are not indicative of a close relationship but perhaps we should not commit ourselves too selectively to statistical results alone. In this instance, the correlation coefficients mask the differences which are apparent when using other means of comparison. This is so because two individuals, one H subject (St.) and one non-H subject (Lu.), showed rather extreme variations from the average scores of the other subjects in their respective groups. That is, the H subject received some very low scores, and the non-H subject some very high scores. These two cases substantially altered the mathematical computations, but might be regarded as the glaring exceptions, so common in psychological tests, when the H-group and non-H-group were taken as wholes. A difference in the coöperative application of two subjects would materially alter their respective standings in a test which at best showed marked individual variability.*

It is apparent, however, that there is no essential difference between the single tasks and the double tasks in their relation to hypnotizability; and consequently although we have hit upon a group of tests which the H-group can execute somewhat more efficiently than the non-H-group, the synchronous performance of two tasks is of no special differentiating value. Our initial hypothesis is not vindicated.

When the results are examined from the point of view of cognifaction (Table 4), a gradation of mutual interference in the tests, which falls conveniently into three groups, is revealed. Dual-task A. with a cognifaction quotient of 17.6 per cent (little interference); dual-tasks B. and C. with cognifaction quotients of 57.2 per cent and 58.2 per cent respectively (medium interference); and dual-task D. with a quotient of 105.8 per cent (great interference).

It may be seen that the number of H subjects in the upper half and the non-H subjects in the lower half of the rank order decreases with the degree of cognifaction. In other words, with an increase in cognifaction and hence mutual interference in the dual-task tests, the H subjects tend to show a decrease in relative efficiency as compared with

* At this point we might cite as an indication of the dubious value of the questionnaire method the instance of one question, the accuracy of the answer to which was tested. The question read: "Can you carry on two fairly complex activities at once?" The subject with the highest average score for the four dual-task tests answered this question: No. 5, whereas the subject who proved himself to be the most inefficient of the group in performing two simultaneous tasks answered this question: Yes 3.

the non-H subjects. In fact in the combination task of sorting cards and anagrams the non-H-group are more efficient than the H-group. This result would suggest that as the difficulty of the tasks increased to the point of demanding two simultaneous cognitive processes of a higher order the non-H-group might be found distinctly more efficient.

In the summary we might say that these experiments fail to demonstrate a significant difference between the H and the non-H-group as regards the ability to perform two simultaneous tasks. The experiments show that to a slight but appreciable extent the efficiency of the H-group is greater than that of the non-H-group in both the single and dual task tests. This may mean either that the H-group have greater general intelligence, or that we have quite by chance selected tests which differentiate the particular type of mentality possessed by the H-group from its opposite. This consideration leads us to examine the question of intelligence as related to hypnotizability.

(*iii*) *Intelligence*

It has generally been considered that dissociability went with a less integrated and hence a less developed and effective mental organization than the normal. According to Janet, for instance, the hysterics are mentally indolent or flighty, whereas the psychasthenics are potential philosophers. This judgment was substantiated by the work of Hollingsworth [6] during the war. He discovered that hysteria, which developed mostly among the privates, was correlated with low scores in the army intelligence tests, and that psychasthenia, which was more common among the officers, was correlated with high scores. So much for hysteria. Our problem being hypnotizability, the question for us to decide was: how does the intelligence of the H-group compare with that of the non-H-group? From our personal acquaintance with the subjects and from their standing in the college examinations the two groups seemed very evenly matched. There was nothing to choose between them.

As added data, the Army Alpha test was given to most of our subjects in 1928 and in 1929. It was found that the coefficient of correlation between the scores on this test and the hypnotic index, for the selected group that took the dual task test, was .03 (f); and that the coefficient of correlation between the Army Alpha test and the hypnotic index for all subjects in both years (59 cases) was .01 (f). Apparently there is no relationship between hypnotizability and the sort of intelligence that is measured by the Army Alpha test. On the other hand,

the correlation between the scores in the dual task test and the Army Alpha was .42 (f). This form of intelligence evidently plays a rôle in the dual task performance. It may indeed be held partly accountable for the low correlation between the H. I. and the scores in the latter test (.23), since the one H subject who ranked very low in the dual task test (Table 3) was seventeenth among the 18 subjects in the Army Alpha, whereas the non-H subject who ranked so high in the dual task test was seventh in the Army Alpha ranking.

CONCLUSION AND SUMMARY

As a result of the experiments described in this paper we conclude that:

(1) Hypnotizability is a trait which may be measured with some degree of reliability.

(2) A standard technique for the measurement of the H. I. (hypnotic index) has been arrived at by which results are expressed quantitatively on a zero to five scale.

(3) Twenty-five per cent of a sample college group were found to be hypnotizable to the extent of complete suggestibility with some amnesia.

(4) A coefficient of correlation of approximately .75 may be expected between two trials of the same test when performed within a week or so of each other by different operators. A coefficient of the same order is obtained when two tests, performed by the same operator but separated by an interval of several months, are correlated with each other.

(5) The results of the hypnotic test as standardized in this study correlate with the score of hypnotic tests done under other conditions (a. group test and b. Hull's swaying test) with a coefficient of .52.

(6) Suggestibility under hypnotic conditions does not correlate with suggestibility under other conditions, that is, when subjects assume their customary attitudes (cf. results in the Hull swaying test and the group suggestibility test).

The problem of explaining hypnosis in terms of needs or instincts has been discussed in the text. All our observations and tests bearing upon this point proved to be negative or inconclusive. There did not seem to be any relation between hypnotizability and submission or between hypnotizability and extraversion.

The problem of explaining hypnosis in terms of aptitude or psychical configuration has also been discussed in the text with special reference

to the concept of dissociation. Several investigations were made to determine the relationship between hypnotizability and other possible manifestations of dissociability, but our results along these lines were likewise negative or indeterminate.

BIBLIOGRAPHY

1. ALLPORT, G. W. and F. H. *Jour. Abn. & Soc. Psych.*, 1928, XXIII, 2.
2. BRAMWELL, J. MILNE. Hypnotism, London, 1921.
3. FREUD, S. Group Psychology and the Analysis of the Ego. Trans. by J. Strachey, New York, 1921.
4. GROSS, OTTO. Die Cerebrale Sekundärfunktion. Vienna, 1902.
5. HINKLE, B. M. The Re-Creating of the Individual. New York, 1923.
6. HOLLINGSWORTH, H. L. The Psychology of Functional Neuroses. New York, 1920.
7. HULL, C. L. *Jour. Abn. & Soc. Psych.*, 1925, XX, 234.
8. JANET, P. L'État mental des hystériques. 2nd Edition, Paris, 1911.
9. ———. Les Obsessions et la Psychasténie. 2nd Edition, Paris, 1903.
10. ———. Névroses et idées fixes. 4th Edition, Paris, 1925.
11. JUNG, C. G. The Psychology of Dementia Praecox. Nervous and Mental Disease Monograph Series No. 3, New York.
12. ———. The Psychology of the Unconscious. New York, 1921.
13. ———. Psychological Types. Trans. by H. G. Baynes, London, 1923.
14. KRETSCHMER, E. Hysteria. Trans. by O. H. Boltz, Nervous and Mental Disease Monograph Series No. 44, New York, 1926.
15. ———. Physique and Character. Trans. by W. J. H. Sprott, London, 1925.
16. LUNDHOLM, H. *Jour. of Nervous & Mental Dis.*, 1926, 64, 125; *Ibid.*, 1928, 68, 456.
17. MESSERSCHMIDT, R. *Jour. Abn. & Soc. Psych.*, 1927, XXII, 325.
18. MOORE, H. T. *Jour. Abn. & Soc. Psych.*, 1925, XX, 234.
19. MCDOUGALL, W. Outline of Abnormal Psychology. New York, 1926.
20. NEYMANN and KOHLSTEDT. *Jour. Abn. & Soc. Psych.*, 1929, XXIII, 482.
21. Personal communication.
22. SPEARMAN, C. The Abilities of Man. New York, 1927.
23. WELLS, W. R. *Jour. Abn. & Soc. Psych.*, 1924, XVIII, 389.
24. WERTHEIMER, F. L., and HESKETH, F. E. The Significance of the Physical Constitution in Mental Disease. Baltimore, 1926.

THE RELATIONSHIP OF INDIVIDUAL GROWTH TO AVERAGE GROWTH*

BY MARGARET MERRELL

INTRODUCTION

Growth changes in the size of biological organisms in whole and in part are being described in increasing number and variety. The study of such changes is hampered by two obstacles—the great length of time required for the complete development of many forms, and the more serious handicap of the impossibility of obtaining measurements on many body parts while the organism is alive. In the latter case the opportunity for direct observation comes only after the mass has ceased to grow. For many forms it is thus difficult or impossible to follow the same individual through its growth process.

Because of these difficulties in obtaining successive growth measurements on the same individual, the method of observing the progress of growth, in the majority of cases, is to measure groups of individuals at different ages and form an average measurement at each age. The description of the growth is then given in terms of the progress of these averages from one age to the next. These growth changes are characterized by a changing rate of growth which produces fluctuations or cycles due to alternating periods of slow and rapid growth. These cycles may be one or more in number and may be skew or symmetrical in form.

In many cases it is advantageous to describe the growth changes by means of equations, since they frequently furnish a concise description of the material, an easy method of smoothing the observations and interpolating between them, and a convenient means of comparing different series of measurements. This method of description has led to

* Papers from the Department of Biostatistics, School of Hygiene and Public Health, The Johns Hopkins University, No. 124. The writer is indebted to Doctor Lowell J. Reed for his suggestions and criticism in this study, and to Doctor Carroll G. Bull for permitting the use of the observations on rabbits measured in his laboratory.

a large number of growth equations and a great diversity of views with regard to them.

Empirical equations are used by some workers in the field who state specifically that they consider such equations merely convenient graduation formulae without any theoretical significance. In this sense, straight lines and second order parabolas are used by Scammon and Calkins [1] to describe the growth of linear dimensions of the human fetus, a simple power function is used by Murray [2] to express the average weight of chicken embryos over a short time period, a generalized logistic is used by Pearl and Reed [3] to smooth various kinds of skew growth material, and many other algebraic and exponential forms are in common use by various writers in the field. A similar approach is frequently made to the description of population growth, when a straight line or exponential curve is used to describe the growth in the number of organisms. Such curves are often of value, as stated above, for the range over which they represent the observations, although the writers in using these equations make no attempt to rationalize the constants or present the curves as "laws of growth."

There are other writers who argue from an empirical equation a law or explanation of the growth process. The objections to this point of view with regard to empirical equations have been discussed in a recent paper by Gray.[4] An instance of this attitude toward the problem is seen in the work of Robertson,[5] who argues from the fact that growth material has the general form of the logistic or autocatalytic curve, that the growth process is controlled by a reaction of chemical autocatalysis. In discussing the form of the curve he states that "the fact that each growth-cycle begins slowly and progressively increases in velocity until the moment of maximal growth-velocity is attained at the center of the cycle, is sufficient in itself to show that the process is autocatalyzed" (p. 6). This argument is dangerous since it implies that any logistic curve must have resulted from an autocatalytic reaction. Furthermore, this reasoning can be used with equal force to set up other theories of growth if other empirical equations can be found which describe the data equally well.

Another attempt to rationalize an empirical equation is made by Brody,[6] who divides the growth observations into several sections to which he fits a series of exponential curves. From this he argues that growth takes place in a series of distinct stages, each having a constant percentage rate. As Gray points out (p. 269) "any curve can be expressed as a series of straight lines or exponential curves if suitable

limits are selected. Unless, therefore, there is good independent evidence that the whole growth cycle is divisible into a finite number of successive and different processes, the process of subdivision of the growth curve is purely arbitrary." This type of analysis gives no explanation, therefore, of the fundamental factors underlying the growth process, but merely gives empirically determined rates of growth at arbitrarily selected positions.

Attempts to develop rational expressions for the rate of growth are made by some investigators (Gray and others) by the direct study of growth factors. In this approach assumptions concerning the underlying factors lead to, rather than follow from, a descriptive equation. This method has been used by Pearl and Reed [7] in developing the logistic curve to describe the growth of populations, which seems to give a very accurate representation of population data. The order of this procedure is more enlightening as to the basic factors in growth than attempts to rationalize fitted equations, although the validity of any result depends on the accuracy of the assumptions and must be tested experimentally. Empirical growth formulae, therefore, may not be considered as explaining the nature of the growth process, but may be useful as graduation equations and as descriptions of rates and accelerations of growth.

In terms of such empirical equations the change in size of organisms or their parts may be described. But since, as we have pointed out, observations on individual growth are usually lacking, the curves describe, not the growth of individuals, but the growth of averages. It is, therefore, of interest to know whether individual curves possess the same characteristics that are exhibited by the average curve. For instance, Scammon and Calkins (p. 51) find that a second order parabola adequately represents the average total body length of fetuses from the third to the tenth lunar month. Since this is the type of growth observation which it is impossible to follow for the same individual, it is important to know whether it is safe to assume that this description of averages is representative also of the growth of individual fetuses in this period.

In most practical cases it is not only assumed that the individual and average growth are of the same type, but that the average may be used as a standard to which normal individuals may be expected to conform. Thus Holt [8] in a paper on standards for growth and nutrition presents the average growth in weight and height for American boys aged 6 to 17 years, and points out the fluctuation in rate of growth which produces a flattening out of the curve between 10 and 12 years of age,

followed by a rapid increase in growth. He considers this flattening out and steep rise of the average curve characteristic also of the growth curves of the individual boys entering into the average.

This question is touched upon by Robertson (p. 3) in discussing the cycles observed in growth material.

> These oscillations in the curve of growth are not accidental. They are readily distinguishable from the minor fluctuations which occur at frequent and irregular intervals in the growth of every individual. These irregular fluctuations . . . . are as frequently positive as they are negative, ... and hence, in the average curve supplied by a sufficient number of individuals, they cancel out and disappear. The large fluctuations, or "Cycles of Growth" as they have been termed, appear always at the same place in the total growth curve of any animals of the same sex and species, and hence, so far from being smoothed out in the average curve from a large number of animals, they are actually emphasized.

That an average curve does not necessarily agree in type with its component curves is shown clearly in the illustration given in Figure 1.

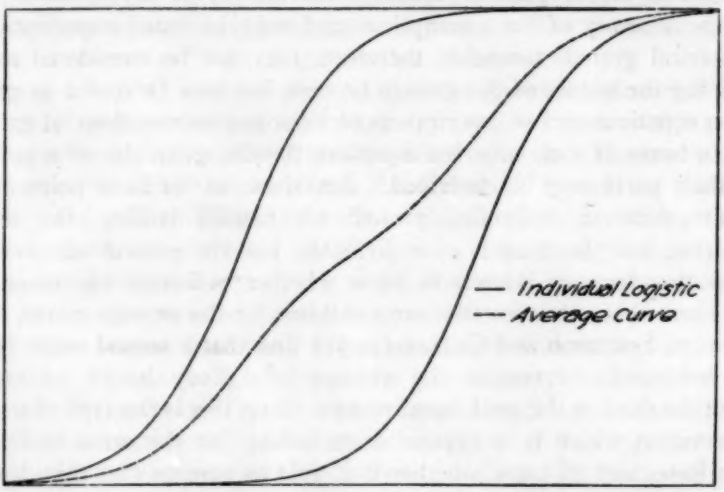


FIG. 1. TWO LOGISTIC CURVES AND THEIR AVERAGE
In this case, two symmetrical logistics (solid lines), average to give a mean curve (broken line) which has two skew cycles.

Since it is clear, therefore, that individual curves and their average do not of necessity exhibit the same characteristics, it is of interest to ask to what extent they may be expected to differ. It is the object of this paper to derive the mean curve and determine its characteristics from a knowledge of the properties of the individual curves by deter-

mining analytically the form of mean curve arising from a group of individuals, all of which can be represented by the same type of growth function. The mean curve will then be compared both by analysis and application with the individual curves in order to determine the extent to which they differ in their basic characteristics.

ANALYSIS

Suppose the growth process to be represented by any function,

$$y = f\,(a, b, c, \ldots., x)$$

where y represents the growing mass, x represents time, and a, b, c, ... are the arbitrary constants of the curve. Then the growth of individuals 1, 2, ..., n will be represented by the equations

$$\begin{aligned} y_1 &= f\,(a_1, b_1, c_1, \ldots., x) \\ y_2 &= f\,(a_2, b_2, c_2, \ldots., x) \\ &\ldots\ldots\ldots\ldots \\ y_n &= f\,(a_n, b_n, c_n, \ldots., x) \end{aligned} \qquad (1)$$

If $\bar{y}$ represents the average size of the individuals at time x, then

$$\bar{y} = \frac{1}{n}[f\,(a_1, b_1, c_1, \ldots., x) + f\,(a_2, b_2, c_2, \ldots., x) + \ldots. + f\,(a_n, b_n, c_n, \ldots., x)] \qquad (2)$$

Expressing the constants for each curve as deviations from the means of the constants for all the curves, and writing

$$a = \bar{a} + \alpha, \quad b = \bar{b} + \beta, \quad c = \bar{c} + \gamma, \text{ etc.},$$

where $\bar{a}$, $\bar{b}$, $\bar{c}$, ... are the mean values of the constants, and α, β, γ . . . . are deviations of the constants from these means we have

$$f\,(a, b, c, \ldots., x) = f\,(\bar{a} + \alpha, \bar{b} + \beta, \bar{c} + \gamma, \ldots., x)$$

Expanding this function by Taylor's series,

$$\begin{aligned} f\,(\bar{a} + \alpha, \bar{b} + \beta, \bar{c} + \gamma, \ldots., x) &= f\,(\bar{a}, \bar{b}, \bar{c}, \ldots., x) \\ &+ \alpha f'_a + \beta f'_b + \gamma f'_c + \ldots. + \tfrac{1}{2!}(\alpha^2 f''_a + \beta^2 f''_b + \gamma^2 f''_c \\ &+ \ldots. + 2\alpha\beta f''_{ab} + 2\alpha\gamma f''_{ac} + 2\beta\gamma f''_{bc} + \ldots.) + \ldots. \end{aligned} \qquad (3)$$

where $f^n_a = \dfrac{\partial^n f}{\partial a^n}$, $f^n_{a^m b^{n-m}} = \dfrac{\partial^n f}{\partial a^m \partial b^{n-m}}$, etc., with the mean values of the constants substituted. (4)

Any individual curve is thus expressed as a series, the first term of which is the same function of x as that representing the individuals, the arbitrary constants being the means of the constants of the separate

curves. The remaining terms of this series express the divergence of the individual curve from the curve $y = f(\bar{a}, \bar{b}, \bar{c}, \ldots, x)$, which throughout this paper will be called the mean-constant curve.

The average of n such curves is, therefore,

$$\begin{aligned}\bar{y} = f(\bar{a}, \bar{b}, \bar{c}, \ldots, x) &+ f'_a\frac{\Sigma a}{n} + f'_b\frac{\Sigma\beta}{n} + f'_c\frac{\Sigma\gamma}{n} + \ldots \\ &+ \tfrac{1}{2!}\left(f''_a\frac{\Sigma a^2}{n} + f''_b\frac{\Sigma\beta^2}{n} + f''_c\frac{\Sigma\gamma^2}{n} + \ldots + 2f''_{ab}\frac{\Sigma a\beta}{n}\right. \\ &\left. + 2f''_{ac}\frac{\Sigma a\gamma}{n} + 2f''_{bc}\frac{\Sigma\beta\gamma}{n} + \ldots\right) + \tfrac{1}{3!}\left(f'''_a\frac{\Sigma a^3}{n} + f'''_b\frac{\Sigma\beta^3}{n}\right. \\ &\left. + f'''_c\frac{\Sigma\gamma^3}{n} + \ldots + 3f'''_{a^2b}\frac{\Sigma a^2\beta}{n} + 3f'''_{a^2c}\frac{\Sigma a^2\gamma}{n} + 3f'''_{ab^2}\frac{\Sigma a\beta^2}{n}\right. \\ &\left. + 3f'''_{ac^2}\frac{\Sigma a\gamma^2}{n} + 3f'''_{b^2c}\frac{\Sigma\beta^2\gamma}{n} + 3f'''_{bc^2}\frac{\Sigma\beta\gamma^2}{n} + 6f'''_{abc}\frac{\Sigma a\beta\gamma}{n} + \ldots\right) \\ &+ \ldots\end{aligned}$$

This series, by definition of mean, standard deviation, and correlation coefficient, becomes

$$\begin{aligned}\bar{y} = f(\bar{a}, \bar{b}, \bar{c}, \ldots, x) &+ \tfrac{1}{2!}\left(\sigma_a^2 f''_a + \sigma_b^2 f''_b + \sigma_c^2 f''_c\right. \\ &\left. + \ldots + 2r_{ab}\sigma_a\sigma_b f''_{ab} + 2r_{ac}\sigma_a\sigma_c f''_{ac} + 2r_{bc}\sigma_b\sigma_c f''_{bc}\right. \\ &\left. + \ldots\right) + \tfrac{1}{3!}\left(f'''_a\frac{\Sigma a^3}{n} + f'''_b\frac{\Sigma\beta^3}{n} + f'''_c\frac{\Sigma\gamma^3}{n} + \ldots\right. \\ &\left. + 3f'''_{a^2b}\frac{\Sigma a^2\beta}{n} + 3f'''_{a^2c}\frac{\Sigma a^2\gamma}{n} + 3f'''_{ab^2}\frac{\Sigma a\beta^2}{n} + 3f'''_{ac^2}\frac{\Sigma a\gamma^2}{n}\right. \\ &\left. + 3f'''_{b^2c}\frac{\Sigma\beta^2\gamma}{n} + 3f'''_{bc^2}\frac{\Sigma\beta\gamma^2}{n} + 6f'''_{abc}\frac{\Sigma a\beta\gamma}{n} + \ldots\right) + \ldots \quad (5)\end{aligned}$$

The arithmetic mean of a set of individual curves is thus expressed as a series whose first term is the mean-constant curve. The remaining terms of the series are composed of higher moments of the constants and successive derivatives of the function with respect to the constants.

Applications of Equation for Mean of any Set of Curves

As applications of the expression for the mean of any set of curves, given in equation (5), we shall consider two functions, the generalized parabola and the logistic, both of which are frequently used as empirical formulae for describing growth changes. We wish to determine the form of curve which would result from averaging a series of individuals represented by each of these functions.

Mean of Parabolas

Suppose the growth of a series of individuals to be represented by parabolas of the form

$$y = a + bx + cx^2 + dx^3 + \ldots . \qquad (6)$$

The individuals 1, 2, ..., n will then be represented by

$$y_1 = a_1 + b_1x + c_1x^2 + d_1x^3 + \ldots .$$
$$y_2 = a_2 + b_2x + c_2x^2 + d_2x^3 + \ldots .$$
$$\ldots \ldots \ldots \ldots \ldots$$
$$y_n = a_n + b_nx + c_nx^2 + d_nx^3 + \ldots .$$

The partial derivatives necessary for expressing the mean, are:

$$f'_a = 1$$
$$f'_b = x$$
$$f'_c = x^2$$
$$f'_d = x^3$$
$$\ldots .$$

and the higher derivatives, as defined in (4) are all 0. Thus the average of the curves is given by

$$\bar{y} = \bar{a} + \bar{b}x + \bar{c}x^2 + \bar{d}x^3 + \ldots . \qquad (7)$$

If a parabola is used as a description of growth, the average of a group of growth curves is thus seen to be a parabola whose constants are the means of the constants of the individual curves (i. e., a mean-constant parabola). The average curve will therefore have the same number of maxima, minima, and points of inflection as the individual curves.

A series of individual curves represented by third order parabolas of the form given in (6) would each have an inflection at $x = -\frac{c}{3d}$ and the mean of these curves would have an inflection at $x = -\frac{\bar{c}}{3\bar{d}}$. In general, any characteristic of an individual curve represented by some function of its constants will for the mean curve be represented by the same function of the mean constants.

Mean of Logistics

Since the mean curve for a group of logistics will be analyzed in some detail, a brief description of the properties of the logistic will be given.

The equation of the logistic may be written

$$y = \frac{K}{1 + e^{a+bx}} \tag{8}$$

where y represents the size of the growing mass, and x the time. The rate of increase in y, that is, the amount of change in the mass in a unit time, is given by the equation

$$\frac{dy}{dx} = -\frac{bKe^{a+bx}}{(1 + e^{a+bx})^2} \tag{9}$$

which by substitution from (8) becomes

$$\frac{dy}{dx} = -\frac{b}{K}\, y\,(K - y) \tag{10}$$

When the logistic is used as an equation representing positive growth, its rate of change must be positive. From (10) it is evident that b must be negative in this case. An analysis of equations (8) and (10) shows the meaning of the constants to be as follows:

(a) K is the upper limit which is approached by the growing mass as x becomes indefinitely large. The curve is enclosed between a lower asymptote $y = 0$ and an upper asymptote $y = K$.

(b) b is dimensionally $\frac{1}{\text{time}}$ and $\frac{1}{b}$ is the natural unit of time. This unit, $\frac{1}{b}$, determines the spread of the curve and has been called the "standard interval" [9] by analogy to the standard deviation.

If K increases indefinitely, equation (10) becomes

$$\frac{dy}{dx} = -by$$

which is the equation of geometric increase, where $-b$ represents the proportional change in y at any instant. It is, therefore, a rate constant, and may be considered the inherent rate of the logistic, which the logistic is prevented from maintaining by its upper limit, K. The curve leaves its lower asymptote and approaches its upper asymptote with the exponential rate $-b$.

(c) a is the constant of integration and is dependent upon the position of the origin. The point of inflection is $-\frac{a}{b}$ units from the origin.

If the origin of time is moved to the point of inflection and time is expressed in units of $\frac{1}{b}$, equation (8) takes the form

$$y = \frac{K}{1 + e^{-x}} \tag{11}$$

This transformation is analogous to the usual procedure in expressing the horizontal scale of the normal curve as deviations from the mean measured in units of standard deviation. Figure 2 presents a graph of equation (11) and shows the important characteristics of the curve.

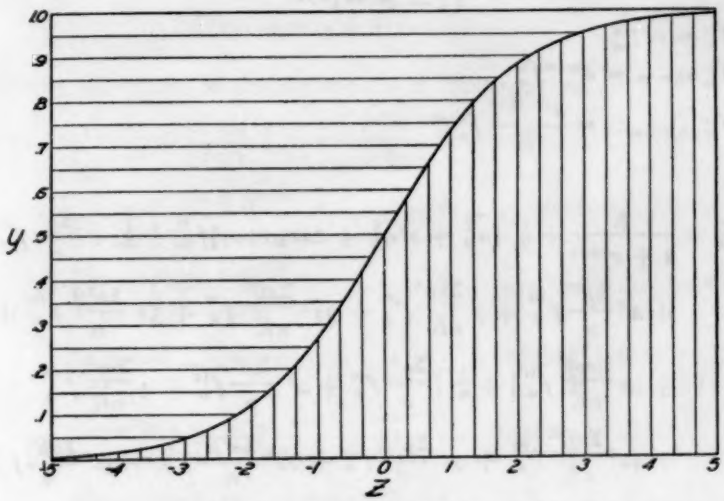


FIG. 2. THE LOGISTIC CURVE

If the growth of a series of individuals can be described by logistic curves, the growth of individuals 1, 2, ..., n being represented by

$$y_1 = \frac{K_1}{1 + e^{a_1 + b_1 z}}$$

$$y_2 = \frac{K_2}{1 + e^{a_2 + b_2 z}}$$

. . . . .

$$y_n = \frac{K_n}{1 + e^{a_n + b_n z}} \qquad (12)$$

then by equation (5) the average growth of these individuals may be represented by

$$\bar{y} = \frac{\bar{K}}{1 + e^{\bar{a} + \bar{b}z}} + \tfrac{1}{2!}[\sigma_a^2 f''_a + \sigma_b^2 f''_b + \sigma_K^2 f''_K + 2r_{ab}\sigma_a\sigma_b f''_{ab}$$

$$+ 2r_{aK}\sigma_a\sigma_K f''_{aK} + 2r_{bK}\sigma_b\sigma_K f''_{bK}] + \ldots . \qquad (13)$$

The derivatives for the logistic are

$$f_{\bar{K}}^{n} = 0, \text{ when } n > 1$$

$$f_{a}^{n} = \frac{-\bar{K}e^{\bar{a}+\bar{b}x}\sum_{r=0}^{n-1}\sum_{s=0}^{r}(-1)^{s}(s+1)^{n}\binom{n+1}{r-s}e^{r(\bar{a}+\bar{b}x)}}{(1+e^{\bar{a}+\bar{b}x})^{n+1}}$$

$$f_{b}^{n} = x^{n}f_{a}^{n}$$

$$f_{a^{n-m}b^{n-m}}^{n} = x^{n-m}f_{a}^{n}$$

$$f_{\bar{K}a^{m}b^{n-m-1}}^{n} = \frac{x^{n-m-1}}{\bar{K}}f_{a}^{n-1}$$

Then

$$\bar{y} = \frac{\bar{K}}{1+e^{\bar{a}+\bar{b}x}} + \tfrac{1}{2!}[\sigma_a^2 + x^2\sigma_b^2 + 2xr_{ab}\sigma_a\sigma_b]f_a'' + \tfrac{1}{3!}\Big[\frac{\Sigma a^3}{n}f_a''' + x^3\frac{\Sigma\beta^3}{n}f_a''' + 3\frac{\Sigma\kappa a^2}{n\bar{K}}f_a'' + 3x^2\frac{\Sigma\kappa\beta^2}{n\bar{K}}f_a'' + 3x\frac{\Sigma a^2\beta}{n}f_a''' + 3x^2\frac{\Sigma a\beta^2}{n}f_a''' + 6x\frac{\Sigma\kappa a\beta}{n\bar{K}}f_a''\Big] + \tfrac{1}{4!}\Big[\frac{\Sigma a^4}{n}f_a^{iv} + x^4\frac{\Sigma\beta^4}{n}f_a^{iv} + 4\frac{\Sigma\kappa a^3}{n\bar{K}}f_a''' + 4x^3\frac{\Sigma\kappa\beta^3}{n\bar{K}}f_a''' + 4x\frac{\Sigma a^3\beta}{n}f_a^{iv} + 6x^2\frac{\Sigma a^2\beta^2}{n}f_a^{iv} + 4x^3\frac{\Sigma a\beta^3}{n}f_a^{iv} + 12x\frac{\Sigma\kappa a^2\beta}{n\bar{K}}f_a''' + 12x^2\frac{\Sigma\kappa a\beta^2}{n\bar{K}}f_a'''\Big] + \ldots.$$

which may be written

$$\bar{y} = \frac{\bar{K}}{1+e^{\bar{a}+\bar{b}x}} + \tfrac{1}{2!}\Big[f_a''\sigma^2_{a+bx} + \frac{2}{\bar{K}}f_a'\frac{\Sigma\kappa'(a+\beta x)}{n}\Big] + \tfrac{1}{3!}\Big[f_a'''\frac{\Sigma(a+\beta x)^3}{n} + \frac{3}{\bar{K}}f''\frac{\Sigma\kappa(a+\beta x)^2}{n}\Big] + \tfrac{1}{4!}\Big[f_a^{iv}\frac{\Sigma(a+\beta x)^4}{n} + \frac{4}{\bar{K}}f_a'''\frac{\Sigma\kappa(a+\beta x)^3}{n}\Big] + \ldots. \qquad (14)$$

This function will take various forms depending on the distribution of the individual curves. It is necessary therefore to make some assumption as to the distribution of the constants of the curves. We shall assume that K, a, and b are normally distributed. These assumptions will assure that the group of logistic curves are reasonably homogeneous as to their asymptotic values, their rates of increase, and their positions on the time scale. Under these assumptions we have

$$\bar{y} = \frac{\bar{K}}{1+e^{\bar{a}+\bar{b}x}} + \frac{1}{2(1!)} f''_{\bar{a}} \sigma^2_{\bar{a}+\bar{b}x} + \frac{1}{2^2(2!)} f^{iv}_{\bar{a}} \sigma^4_{\bar{a}+\bar{b}x} + \frac{1}{2^3(3!)} f^{vi}_{\bar{a}} \sigma^6_{\bar{a}+\bar{b}x}$$
$$+ \ldots + \frac{\sigma_K}{\bar{K}} f'_{\bar{a}} r_{K(\bar{a}+\bar{b}x)} \sigma_{\bar{a}+\bar{b}x} + \frac{\sigma_K}{2(1!)\bar{K}} f'''_{\bar{a}} r_{K(\bar{a}+\bar{b}x)} \sigma^2_{\bar{a}+\bar{b}x}$$
$$+ \frac{\sigma_K}{2^2(2!)\bar{K}} f^{v}_{\bar{a}} r_{K(\bar{a}+\bar{b}x)} \sigma^5_{\bar{a}+\bar{b}x} + \ldots . \qquad (15)$$

Substituting the values of the derivatives in this equation

$$\bar{y} = \frac{\bar{K}}{1+e^{\bar{a}+\bar{b}x}} + \frac{\sigma^2_{\bar{a}+\bar{b}x}}{2(1!)} \left[\frac{-\bar{K}e^{\bar{a}+\bar{b}x}}{(1+e^{\bar{a}+\bar{b}x})^3} (1 - e^{\bar{a}+\bar{b}x}) \right]$$
$$+ \frac{\sigma^4_{\bar{a}+\bar{b}x}}{2^2(2!)} \left[\frac{-\bar{K}e^{\bar{a}+\bar{b}x}}{(1+e^{\bar{a}+\bar{b}x})^5} (1 - 11e^{\bar{a}+\bar{b}x} + 11e^{2(\bar{a}+\bar{b}x)} - e^{3(\bar{a}+\bar{b}x)}) \right]$$
$$+ \frac{\sigma^6_{\bar{a}+\bar{b}x}}{2^3(3!)} \left[\frac{-\bar{K}e^{\bar{a}+\bar{b}x}}{(1+e^{\bar{a}+\bar{b}x})^7} (1 - 57e^{\bar{a}+\bar{b}x} + 302e^{2(\bar{a}+\bar{b}x)} - 302e^{3(\bar{a}+\bar{b}x)} \right.$$
$$\left. + 57e^{4(\bar{a}+\bar{b}x)} - e^{5(\bar{a}+\bar{b}x)}) \right] + \ldots . + \frac{\sigma_{\bar{a}+\bar{b}x}\sigma_K r_{K(\bar{a}+\bar{b}x)}}{\bar{K}} \left[\frac{-\bar{K}e^{\bar{a}+\bar{b}x}}{(1+e^{\bar{a}+\bar{b}x})^2} \right]$$
$$+ \frac{\sigma^3_{\bar{a}+\bar{b}x}\sigma_K r_{K(\bar{a}+\bar{b}x)}}{2(1!)\bar{K}} \left[\frac{-\bar{K}e^{\bar{a}+\bar{b}x}}{(1+e^{\bar{a}+\bar{b}x})^4} (1 - 4e^{\bar{a}+\bar{b}x} + e^{2(\bar{a}+\bar{b}x)}) \right]$$
$$+ \frac{\sigma^5_{\bar{a}+\bar{b}x}\sigma_K r_{K(\bar{a}+\bar{b}x)}}{2^2(2!)\bar{K}} \left[\frac{-\bar{K}e^{\bar{a}+\bar{b}x}}{(1+e^{\bar{a}+\bar{b}x})^6} (1 - 26e^{\bar{a}+\bar{b}x} + 66e^{2(\bar{a}+\bar{b}x)} \right.$$
$$\left. - 26e^{3(\bar{a}+\bar{b}x)} + e^{4(\bar{a}+\bar{b}x)}) \right] + \ldots . \qquad (16)$$

Now, let $\bar{a} + \bar{b}x = -z$

Since $\bar{b}$ is negative, z is given the negative sign in order that the function may have the same value when x and z have the same sign.

Then $$x = -\frac{z}{\bar{b}} - \frac{\bar{a}}{\bar{b}}$$

and $$a + bx = a + b\left(-\frac{z}{\bar{b}} - \frac{\bar{a}}{\bar{b}}\right)$$
$$= a - \frac{\bar{a}}{\bar{b}} - \frac{b}{\bar{b}} z$$

Let $$a' = a - \frac{\bar{a}}{\bar{b}}$$

and $$b' = -\frac{b}{\bar{b}}$$

Then $$a + bx = a' + b'z \qquad (17)$$

In this equation the origin is moved to the position $-\frac{\bar{a}}{\bar{b}}$, 0 and time is expressed in units of $\frac{1}{\bar{b}}$. In this transformation, the y axis passes through the point of inflection of the mean-constant logistic, and time is expressed in terms of the "standard interval."

Substituting $-z$ for $\bar{a} + \bar{b}x$ in equation (16)

$$\bar{y} = \frac{\bar{K}}{1+e^{-z}} + \frac{\sigma^2_{a'}+b'z}{2(1!)}\left[\frac{-\bar{K}e^{-z}}{(1+e^{-z})^3}(1-e^{-z})\right]$$
$$+ \frac{\sigma^4_{a'}+b'z}{2^2(2!)}\left[\frac{-\bar{K}e^{-z}}{(1+e^{-z})^5}(1-11e^{-z}+11e^{-2z}-e^{-3z})\right]$$
$$+ \frac{\sigma^6_{a'}+b'z}{2^3(3!)}\left[\frac{-\bar{K}e^{-z}}{(1+e^{-z})^7}(1-57e^{-z}+302e^{-2z}-302e^{-3z}\right.$$
$$\left.+57e^{-4z}-e^{-5z})\right]+\ldots\ldots+\frac{\sigma_{a'}+b'z\sigma_K r_{K(a'+b'z)}}{\bar{K}}\left[\frac{-\bar{K}e^{-z}}{(1+e^{-z})^2}\right]$$
$$+ \frac{\sigma^3_{a'}+b'z\sigma_K r_{K(a'+b'z)}}{2(1!)\bar{K}}\left[\frac{-\bar{K}e^{-z}}{(1+e^{-z})^4}(1-4e^{-z}+e^{-2z})\right]$$
$$+ \frac{\sigma^5_{a'}+b'z\sigma_K r_{K(a'+b'z)}}{2^2(2!)\bar{K}}\left[\frac{-\bar{K}e^{-z}}{(1+e^{-z})^6}(1-26e^{-z}+66e^{-2z}-26e^{-3z}\right.$$
$$\left.+e^{-4z})\right]+\ldots. \qquad (18)$$

Now

$$r_{K(a'+b'z)} = \frac{\Sigma K(a'+b'z)}{n(\sigma_{a'+b'z})\sigma_K}$$
$$= \frac{r_{Ka'}\sigma_{a'}+zr_{Kb'}\sigma_{b'}}{\sigma_{a'+b'z}}$$

and, if we use v_b and v_K as $\frac{\sigma_b}{\bar{b}}$ and $\frac{\sigma_K}{\bar{K}}$ respectively, we have

$$\bar{y} = \frac{\bar{K}}{1+e^{-z}} + \bar{K}\left\{\frac{-e^{-z}}{(1+e^{-z})^2}(r_{Ka'}v_K\sigma_{a'}+zr_{Kb'}v_Kv_b\right.$$
$$+ \frac{\sigma^2_{a'}+b'z}{2(1!)}\left[\frac{-e^{-z}(1-e^{-z})}{(1+e^{-z})^3}+\frac{-e^{-z}(1-4e^{-2z})}{(1+e^{-z})^4}(r_{Ka'}v_K\sigma_{a'}\right.$$
$$\left.+zr_{Kb'}v_Kv_b)\right]+\frac{\sigma^4_{a'}+b'z}{2^2(2!)}\left[\frac{-e^{-z}(1-11e^{-z}+11e^{-2z}-e^{-3z}}{(1+e^{-z})^5}\right.$$
$$\left.\left.+\frac{-e^{-z}(1-26e^{-z}+66e^{-2z}-26e^{-3z}+e^{-4z}}{(1+e^{-z})^6}(r_{Ka'}v_K\sigma_{a'}+zr_{Kb'}v_Kv_b)\right]\right.$$

$$+\frac{\sigma_{a'}^6+b'z}{2^3(3!)}\left[\frac{-e^{-z}(1-57e^{-z}+302e^{-2z}-302e^{-3z}+57e^{-4z}-e^{-5z}}{(1+e^{-z})^7}\right.$$

$$\left.+\frac{-e^{-z}(1-120e^{-z}+1191e^{-2z}-2416e^{-3z}+1191e^{-4z}-120e^{-5z}+e^{-6z}}{(1+e^{-z})^8}\right.$$

$$\left.(r_{Ka'}v_K\sigma_{a'}+zr_{Kb'}v_Kv_b)\right]+\ldots.\Bigg\} \qquad (19)$$

The average of a set of logistics is thus a mean-constant logistic plus a series of correction terms. These correction terms form a power series in $\sigma_{a'}^2+b'z$, the coefficients containing successive derivatives of the logistic with respect to the constant a. The values of the first seven derivatives which are necessary for obtaining the first four correction terms, are given in Table 1 for an average K of 1.

TABLE 1

Successive Derivatives of the Logistic from the First to the Seventh ($K=1$)

z	f'	f''	f'''	f^{iv}	f^{v}	f^{vi}	f^{vii}
−5.0	−.006648	+.006559	−.006383	+.006036	−.005357	+.004047	−.001221
−4.5	−.010866	+.010628	−.010158	+.009242	−.007478	+.004150	+.001926
−4.0	−.017663	+.017027	−.015791	+.013418	−.008965	+.000895	+.009051
−3.5	−.028453	+.026785	−.023596	+.017640	−.006930	−.015039	+.038159
−3.0	−.045177	+.040892	−.032931	+.018723	+.004987	−.039904	+.078073
−2.5	−.070104	+.059469	−.040617	+.009441	+.035990	−.085456	+.092054
−2.0	−.104994	+.079962	−.038851	−.020784	+.086826	−.106437	−.048002
−1.5	−.149147	+.094731	−.015679	−.074815	+.120069	+.005618	−.426162
−1.0	−.196613	+.090858	+.035326	−.123508	+.051042	+.283436	−.563093
−0.5	−.235004	+.057557	+.096357	−.104757	−.135621	+.390322	+.291670
0.0	−.250000	0.000000	+.125000	0.000000	−.250000	0.000000	+1.062500
+0.5	−.235004	−.057557	+.096357	−.104757	−.135621	+.390322	+.291670
+1.0	−.196613	−.090858	+.035326	+.123508	+.051042	−.283436	−.563093
+1.5	−.149147	−.094731	−.015679	+.074815	+.120069	−.005618	−.426162
+2.0	−.104994	−.079962	−.038851	+.020784	+.086826	+.106437	−.048002
+2.5	−.070104	−.059469	−.040617	−.009441	+.035990	+.085456	+.092054
+3.0	−.045177	−.040892	−.032931	−.018723	+.004987	+.039904	+.078073
+3.5	−.028453	−.026785	−.023596	−.017640	−.006930	+.015039	+.038159
+4.0	−.017663	−.017027	−.015791	−.013418	−.008965	−.000895	+.009051
+4.5	−.010866	−.010628	−.010158	−.009242	−.007478	−.004150	+.001926
+5.0	−.006648	−.006559	−.006383	−.006036	−.005357	−.004047	−.001221

To illustrate the evaluation of these terms we shall assume measures of correlation and variation to have the following values:

$$\begin{aligned} r_{Ka'} &= 0 & \sigma_{a'} &= .3 \\ r_{Kb'} &= .5 & v_b &= .2 \\ r_{a'b'} &= .5 & v_K &= .2 \end{aligned} \qquad (20)$$

Table 2 gives the value of the mean of a series of logistics defined by these assumptions, and shows how the mean is built up from the mean-constant logistic and a series of correction terms. Figure 3 shows the wave-like form and the comparative size of these correction terms. It is clear that the predominant term is the second, and the following terms decrease rapidly in size. The correction terms are not symmetrical, more being subtracted from the mean-constant curve to the right of the point of inflection than is added to it to the left of this point. The size of the correction terms in comparison with the mean-constant curve, and the resulting mean curve, is shown in Figure 4. Only the first two terms are large enough to be plotted. For this example the mean curve does not at any point differ from the mean-constant curve by more than 2 per cent of the asymptote.

TABLE 2

The Mean of a Family of Logistics Defined by Assumption (20) with the Separate Terms of the Series ($K = 1$)

z	MEAN OF LOGISTICS (CORRECT TO 5 TERMS)	MEAN-CONSTANT LOGISTIC	CORRECTION TERMS			
			1st Term	2nd Term	3rd Term	4th Term
−5.0	+.010756	+.006693	+.000665	+.002843	+.000513	+.000043
−4.5	+.016113	+.010987	+.000978	+.003636	+.000492	+.000021
−4.0	+.024305	+.017986	+.001413	+.004481	+.000424	+.000000
−3.5	+.036856	+.029312	+.001992	+.005261	+.000310	−.000019
−3.0	+.056073	+.047426	+.002711	+.005787	+.000168	−.000018
−2.5	+.085228	+.075858	+.003505	+.005842	+.000034	−.000013
−2.0	+.128645	+.119203	+.004200	+.005299	−.000051	−.000005
−1.5	+.191105	+.182426	+.004474	+.004284	−.000079	+.000000
−1.0	+.275955	+.268942	+.003932	+.003155	−.000076	+.000002
−0.5	+.381810	+.377541	+.002350	+.001981	−.000065	+.000003
0.0	+.500000	+.500000	0.000000	−.000000	−.000000	−.000000
+0.5	+.616636	+.622459	−.002350	−.003679	+.000224	−.000018
+1.0	+.719082	+.731058	−.003932	−.008564	+.000562	−.000042
+1.5	+.800955	+.817574	−.004474	−.012852	+.000715	−.000008
+2.0	+.862041	+.880797	−.004200	−.015081	+.000415	+.000110
+2.5	+.905561	+.924141	−.003505	−.015067	−.000229	+.000221
+3.0	+.935678	+.952574	−.002711	−.013503	−.000914	+.000232
+3.5	+.956067	+.970688	−.001992	−.011233	−.001414	+.000182
+4.0	+.970065	+.982014	−.001413	−.008871	−.001662	−.000003
+4.5	+.979453	+.989013	−.000978	−.006752	−.001697	−.000133
+5.0	+.985820	+.993307	−.000665	−.005002	−.001587	−.000233

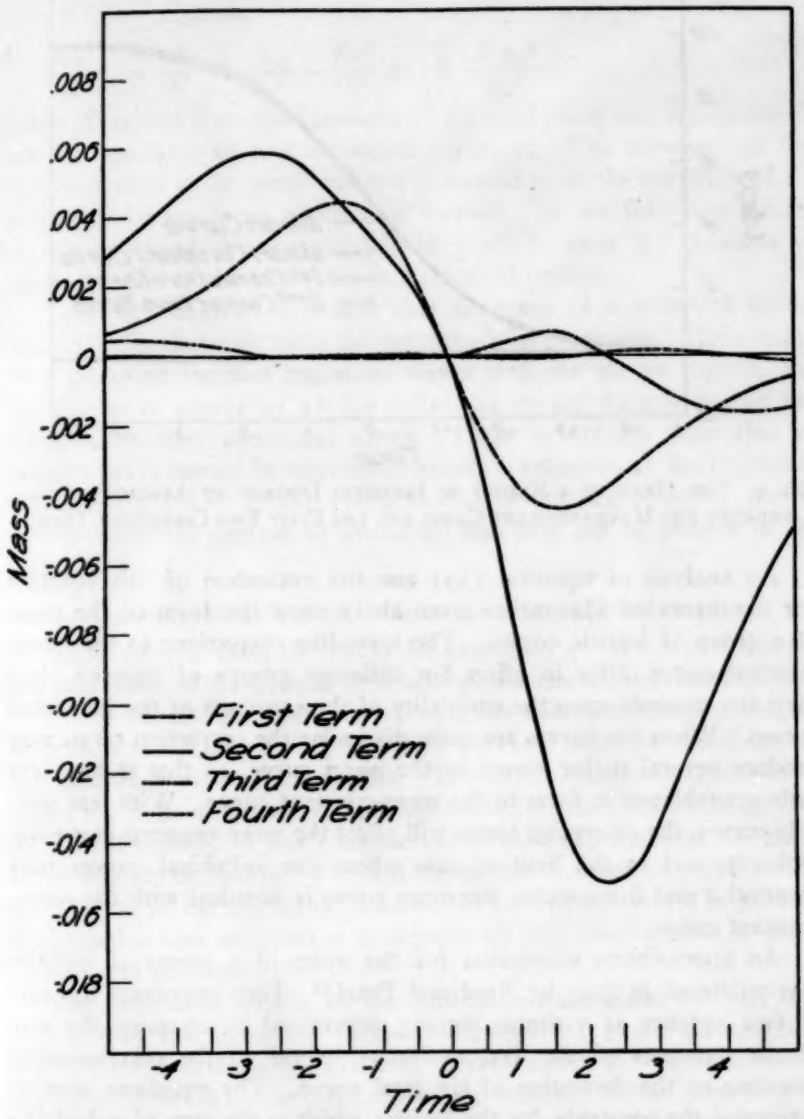


FIG. 3. THE FIRST FOUR CORRECTION TERMS TO THE MEAN-CONSTANT LOGISTIC IN THE EQUATION FOR THE MEAN OF A FAMILY OF LOGISTICS, DEFINED BY ASSUMPTION (20)

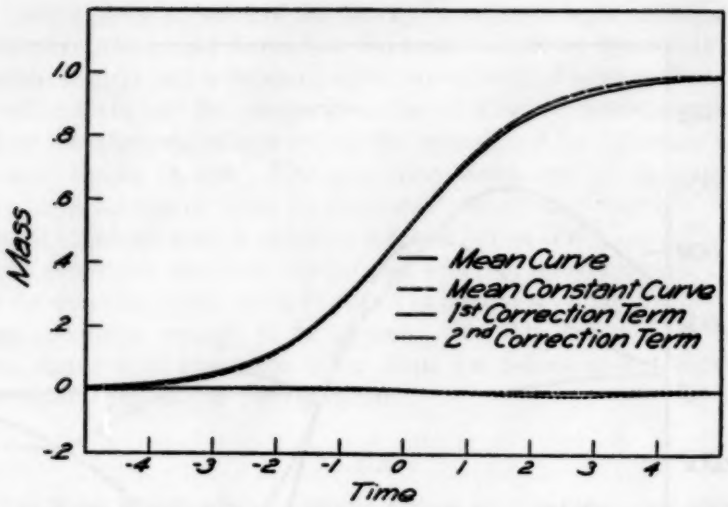


FIG. 4. THE MEAN OF A FAMILY OF LOGISTICS DEFINED BY ASSUMPTION (20), SHOWING THE MEAN-CONSTANT CURVE AND THE FIRST TWO CORRECTION TERMS

An analysis of equation (19) and the evaluation of this equation for the numerical illustration given above show the form of the mean of a group of logistic curves. The wave-like corrections to the mean-constant curve differ in effect for different groups of logistics since their size depends upon the variability of the constants of the individual curves. When the curves are quite dissimilar the correction terms may produce several major waves in the mean curve, so that it has very little resemblance in form to the mean-constant curve. With less variable curves, the correction terms will affect the mean-constant curve less violently, and in the limiting case where the individual curves have identical a and b constants, the mean curve is identical with the mean-constant curve.

An approximate expression for the mean of a group of logistics was published in 1927 by Reed and Pearl.[10] They expressed the sum of two logistics as a simple logistic determined by equating the sum of the moments of the first derivative curves to the corresponding moments of the derivative of the total curve. The equations used to determine the constants for the logistic which is the sum of n logistics are

$$K = \sum_{a=1}^{n} K_a$$

$$\frac{Ka}{\dot{o}} = \sum_{a=1}^{n} \frac{K_a a_a}{b_a} \tag{21}$$

$$\frac{K\pi^2}{3b^2} = \frac{\pi^2}{3} \sum_{a=1}^{n} \frac{K_a}{b_a^2} - \frac{Ka^2}{b^2} + \sum_{a=1}^{n} \frac{K_a a_a^2}{b_a^2}$$

where K, a, and b are the constants of the total curve and K_a, a_a and b_a are the constants of any individual curve, y_a. The closeness of this approximation to the mean curve will depend upon the variation of the individual curves from which it is formed. In the following section an application of this method will be given to show the closeness of approximation to the true mean in a practical problem.

From this analysis it is seen that the mean of a group of curves may differ in character from the individuals in the group. The average of a group of logistics has more waves than the simple logistic, and the degree of similarity of the individual curves determines the importance of these additional waves. These differences show that an average curve cannot be considered merely a reflection of the individual curves since it may exhibit characteristics which are primarily due to the mathematical process of averaging and may not be present in the individuals.

APPLICATION OF THEORY FOR AVERAGING GROWTH CURVES

As an illustration of the theory for averaging growth curves, a study has been made of the growth in weight of a series of individual rabbits.

The group studied consisted of forty-six individuals whose weights were recorded at approximately weekly intervals from the age of one or two months to five or six months. The object of the analysis was to obtain the form of the average growth curve from a study of the growth of the individuals, in order to see the relationship between the mean curve and the individual curve and the extent to which they differed in type, owing to the averaging process. From this analysis it is possible to determine how adequate a description of individual growth is given by averaged observations.

The growth in weight of the rabbits selected could be described very well by simple logistic curves. The approach to the problem was to fit a logistic to the weights of each individual and to express the average curve in terms of the constants of the separate curves, according to equation (19) developed in the preceding section. The form of this mean curve could then be compared with the form of the individual curves. Since the first term in the equation for the mean is the mean-constant logistic, and therefore a centering curve of the same type as

the individuals, this curve was a natural one to compare with the mean. This comparison showed the extent to which the mean curve varied in type from the individuals, due to the correction terms.

The mean curve was compared with another centering logistic—that obtained by the theory of Reed and Pearl for summing logistic curves, discussed in the preceding section. This curve is an approximation to the mean curve determined by fitting a simple logistic to the sums of certain functions of the separate component curves, and therefore furnishes a second comparison of the characteristics of the mean curve and the individual curves.

A further centering curve was obtained by the usual procedure of fitting a descriptive curve to the averages of the observations. This process is the one ordinarily followed in practice, since in most practical problems individual curves are lacking and the average observations at certain intervals are the only available data. It is of interest, therefore, to see how adequate a description such data give of the mean growth of the individuals. In this case the descriptive curve used was a simple logistic and the values of this curve were compared with the mean curve which describes the continuous average of the observations.

The average of a group of individuals is thus shown in comparison with three centering curves of the same form as the individual curves: first, the mean-constant logistic; second, the logistic determined by Reed's and Pearl's summation theory; and third, the logistic fitted to the group averages of the observations.

Method of Fitting Individual Curves

The weights of the individual rabbits were fitted by logistic curves of the form

$$y = \frac{K}{1 + e^{a+bx}}$$

where y is weight in grams and x is age in days from birth. The constants to be determined are K, the upper limit, b, the inherent rate constant, and a, the constant of integration dependent upon the position of the origin. The point of inflection is $-\frac{a}{b}$ days from birth, and is the age at which half the growth is attained.

These constants cannot be determined directly by the method of least squares using the y deviations from the mean as residuals. If we write the equation in the form

$$a + bx = \log_e \frac{K - y}{y} \qquad (22)$$

we have a statement that the logarithm of $\frac{K-y}{y}$ is a linear function with age. $\frac{K-y}{y}$ will therefore plot as a straight line on arithlog paper. In this form, if K be determined by some method of approximation, so that the residual $\log_e \frac{K-y}{y}$ can be set up, the constants a and b can be determined by least squares. For points near either asymptote, small y deviations from the curve result in large deviations of the form $\log \frac{K-y}{y}$, from the straight line. These deviations may influence the determination of a and b to such an extent that the major portion of the curve will not be well fitted. This method does not work well, therefore, if the material runs very close to either asymptote unless the observations are very smooth. This method of fit was adopted in this illustration, although in a number of cases large deviations near the asymptotes made it necessary to drop some points in determining the a and b constants. In order to make clear the application of this method of fit, the steps involved will be outlined.

1. *The determination of K*

From the graph of the weights plotted against time on arithmetic paper, an estimate can be made of K, the upper limit which the weight approaches. Using the estimated value of K, $\frac{K-y}{y}$ is calculated for each observation. These values are plotted against x on arithlog paper. If K has been correctly estimated, this plot will be a straight line; if the assumed K is too low, the plot will curve downward; if too high, it will curve upward. By trial, therefore, K can be determined such that $\frac{K-y}{y}$ will plot as a straight line on arithlog paper. This method works well when the observations extend over the major portion of the range, which is the case with the present illustration. Figure 5 shows the plot of $\frac{K-y}{y}$ against x on arithlog paper for rabbit number A-1. Since all the observations were taken to the nearest hundredth of a kilogram, no attempt was made to estimate K closer than tenths of a kilogram.

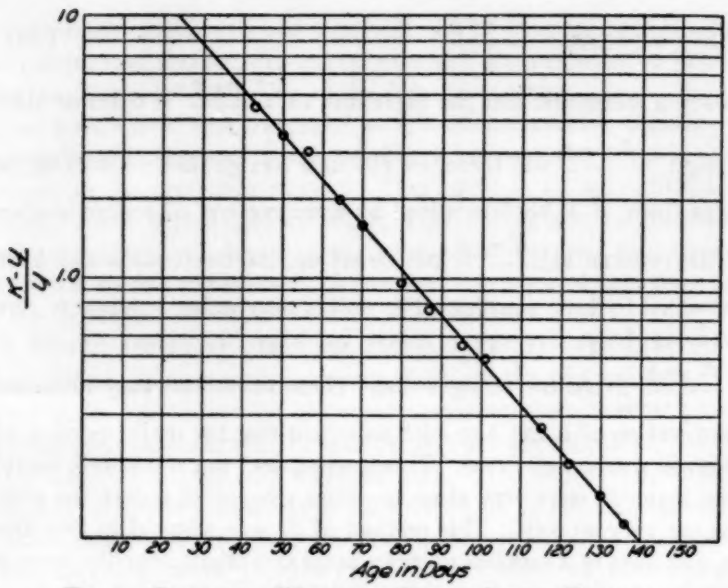


FIG. 5. GROWTH IN WEIGHT OF RABBIT A-1, IN TERMS OF LOG $\frac{K-y}{y}$ PLOTTED AGAINST AGE

2. The determination of a and b

With the value of K determined, $\log_e \frac{K-y}{y}$ can be computed for every observation, and the usual normal equations for a straight line fit by least squares can be set up. In practice it is more convenient to use the logarithms to the base 10.

Letting

$$A = a \log e$$
$$B = b \log e$$

the normal equations are

$$nA + \Sigma xB = \Sigma \log \frac{K-y}{y}$$
$$\Sigma xA + \Sigma x^2 B = \Sigma x \log \frac{K-y}{y}$$

The values of a and b are determined by the solution of these equations. Figure 6 shows the curve fitted by this method to the observed weights of rabbit A-1. By the process just outlined and illustrated for rabbit A-1, constants were obtained for logistics fitted to the 46 individual series of measurements.

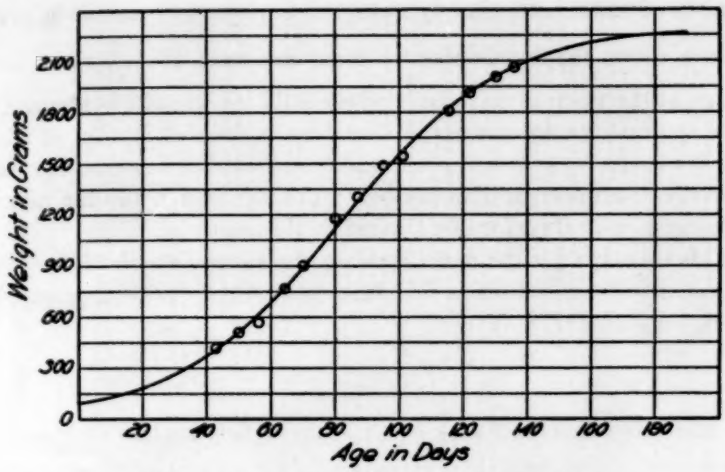


FIG. 6. GROWTH IN WEIGHT OF RABBIT A-1

Constants of the Individual Curves

In terms of the constants of the separate growth curves, the mean curve can be set up and its relationship to the individual curves determined. The expression for the mean curve [equation (19)] was developed on the assumption that K, a, and b are normally distributed. Before applying this theory it is therefore necessary to examine the distribution of these constants. The origin for these curves is taken at

TABLE 3

Distribution of Constants of Individual Rabbit Curves

K (grams)	FREQUENCY	$-b$	FREQUENCY	a	FREQUENCY	$-\frac{a}{b}$ (days)	FREQUENCY
1700-1800	5	.016-.018	1	1.6-1.7	2	64-67	7
1900-2000	11	.019-.021	1	1.8-1.9	3	68-71	3
2100-2200	7	.022-.024	1	2.0-2.1	5	72-75	6
2300-2400	7	.026-.027	10	2.2-2.3	9	76-79	6
2500-2600	5	.028-.030	10	2.4-2.5	8	80-83	6
2700-2800	5	.031-.033	8	2.6-2.7	8	84-87	9
2900-3000	2	.037-.039	6	3.0-3.1	5	92-95	1
3100-3200	3	.034-.036	6	2.8-2.9	3	88-91	5
3300-3400	1	.040-.042	2	3.2-3.3	2	96-99	2
		.043-.045	1	3.4-3.5	0	100-103	1
				3.6-3.7	1		
Total	46	Total	46	Total	46	Total	46

the birth of the animal, time is measured in days, and weight in grams. Table 3 shows the distribution of these constants as well as of $-\frac{a}{b}$, the age at the point of inflection, where half the growth is attained.

In spite of the appearance of skewness in the distribution of K, the three constants K, a, and b, when tested statistically, show no significant difference from normal distributions. The expression for the mean of the logistics may therefore be applied to this material.

This equation for the mean involves the means, standard deviations, and coefficients of variation of these constants. Table 4 gives their values, computed directly.

TABLE 4

Mean and Dispersion Values for Constants of Individual Rabbit Curves

CONSTANT	MEAN	STANDARD DEVIATION	STANDARD DEVIATION / MEAN
K	2321.7	429.3	.1849
a	2.5080	.4282	.1707
b	—.031561	.005634	.1785
$-\frac{a}{b}$	80.161	9.483	.1183

The cluster of curves whose constants have just been summarized, together with the mean of these curves, is represented graphically in Figure 7. It is not possible in this graph to distinguish to any great extent the features of the individual curves, but the type of cluster which these means and variability constants describe is indicated. That this variability is not extreme is shown by the variation of weight described by several observers. In different strains of rabbits studied by Castle [11] the coefficient of variation of mature weight ranged from 6 to 14 per cent. For man, variation in weight at different ages has been the subject of a number of studies. Pearson [12] found the coefficient of variation for male new-born infants 16 per cent and for male adults 11 per cent. The work of several writers analyzed in a recent study of growth changes in correlation by Berkson [13] shows coefficients of variation ranging from 10 to 19 per cent for different ages. This indicates that variation much greater than that met in this illustration would not be likely to be encountered in homogeneous material.

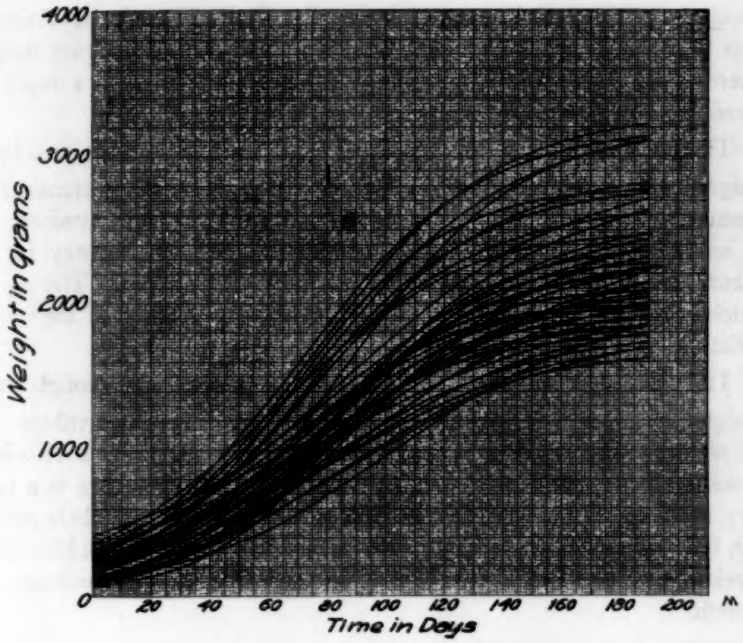


FIG. 7. GROUP OF LOGISTIC CURVES FITTED TO GROWTH IN WEIGHT OF INDIVIDUAL RABBITS, AND THE MEAN OF THESE CURVES

In dealing with a group of curves of this kind, there are a number of features of interest other than central tendencies and dispersion. We have curves varying in their upper limits, their rates of growth, and their points of inflection. In getting a view of the form of the curves, it is important to know whether there is any association between the rapidity of growth and the ultimate size attained, between the ultimate growth and the age at which half the growth is reached, and between rapidity of growth and the age at which the animal is half grown. These questions of relationship are answered by the following correlation coefficients:

$$r_{Kb} = .093 \pm .100$$
$$r_{K(-\frac{a}{b})} = .040 \pm .100$$
$$r_{b(-\frac{a}{b})} = .412 \pm .084$$

The fact that r_{Kb} is not significantly different from zero means that in this group of animals there is no evidence that the adult weight is

associated with the initial rate of growth. A rapid early development is as likely to be associated with a small as with a large mature weight. There is no evidence that a large size is achieved through a rapid inherent growth rate rather than a slow rate.

The correlation between K and $(-\frac{a}{b})$ also differs from zero by an insignificant amount. There is thus no evidence of a relationship between adult size and the age at which half this weight is attained. If an animal is half grown at a young age there is no tendency for his mature weight to be larger or smaller than the average. The age at which half his ultimate weight is reached and the amount of the weight at that age are therefore unrelated.

The correlation between b and $(-\frac{a}{b})$ is positive and though small, is significant in the light of its probable error. Since the values of b are negative, this correlation states that a slow initial rate is associated to some extent with a late point of inflection. That is, there is a tendency for animals starting their growth slowly to reach half their growth at a later age than those which have a rapid initial growth, although as previously stated these factors are unrelated to the size of their ultimate growth.

The Mean of the Growth Curve

With the constants of the individual growth curves determined, it is possible to express the mean of these curves correct to as many terms as we like by following equation (19). In computing these terms it is convenient, as before, to translate the origin to the position $-\frac{\bar{a}}{\bar{b}}$, so that the y axis goes through the point of inflection of the mean-constant curve, and to express time in units of $\frac{1}{\bar{b}}$. Table 5 gives the mean curve correct to five terms and shows how it is built up from the mean-constant logistic and the first four correction terms. In this table z is time expressed in units of "standard interval" from an origin at $-\frac{\bar{a}}{\bar{b}}$, and x is time expressed in days from birth. Since birth occurs when z is approximately -2.5, the values prior to that have no practical significance for this illustration, but are included to show the form of the curves over a wide range. The mean curve thus built up is the actual average of these 46 logistics and may be taken as a standard of comparison for other centering curves.

TABLE 5

The Mean of the Individual Rabbit Curves with the Separate Terms of the Series

z (TIME IN UNITS OF $\frac{1}{b}$ FROM $-\frac{\bar{a}}{b}$)	x (TIME IN DAYS FROM BIRTH)	(1) MEAN OF LOGISTICS (CORRECT TO FIVE TERMS)	(2) MEAN-CONSTANT LOGISTIC	(3) CORRECTION TERMS				(4) (1)—(2)	(5) $\frac{(4)}{(1)}$	(6) $\frac{(4)}{K}$
				First Term	Second Term	Third Term	Fourth Term			
—5.0	— 78.96	+ 21.88	+ 15.54	+ .21	+ 5.25	+ .82	+.06	+ 6.34	+.2898	+.0027
—4.5	— 63.12	+ 33.51	+ 25.51	+ .30	+ 6.85	+ .82	+.03	+ 8.00	+.2387	+.0034
—4.0	— 47.27	+ 51.58	+ 41.76	+ .43	+ 8.65	+ .74	+.00	+ 9.82	+.1904	+.0042
—3.5	— 31.43	+ 79.65	+ 68.06	+ .59	+10.46	+ .57	—.03	+11.59	+.1455	+.0050
—3.0	— 15.59	+ 123.14	+ 110.11	+ .78	+11.94	+ .34	—.03	+13.03	+.1058	+.0056
—2.5	+ .25	+ 189.78	+ 176.12	+ .95	+12.64	+ .09	—.03	+13.66	+.0720	+.0059
—2.0	+ 16.10	+ 289.84	+ 276.76	+1.05	+12.15	— .10	—.01	+13.08	+.0451	+.0056
—1.5	+ 31.94	+ 434.73	+ 423.55	+ .96	+10.42	— .20	+.00	+11.18	+.0257	+.0048
—1.0	+ 47.78	+ 632.66	+ 624.41	+ .56	+ 7.88	— .20	+.01	+ 8.25	+.0130	+.0036
—0.5	+ 63.62	+ 880.40	+ 876.55	— .73	+ 4.73	— .15	+.01	+ 3.85	+.0044	+.0017
0.0	+ 79.46	+1159.81	+1160.87	—1.08	+ .02	— .00	+.00	— 1.06	—.0009	—.0005
+0.5	+ 95.31	+1436.33	+1445.19	—1.86	— 7.35	+ .37	—.03	— 8.86	—.0062	—.0038
+1.0	+111.15	+1679.63	+1697.33	—2.26	—16.25	+ .86	—.05	—17.70	—.0105	—.0076
+1.5	+126.99	+1873.38	+1898.19	—2.25	—23.57	+1.01	—.00	—24.81	—.0132	—.0107
+2.0	+142.83	+2016.67	+2044.98	—1.96	—27.00	+ .52	+.12	—28.31	—.0140	—.0122
+2.5	+158.68	+2117.41	+2145.62	—1.56	—26.50	— .38	+.23	—28.21	—.0133	—.0122
+3.0	+174.52	+2185.99	+2211.63	—1.17	—23.41	—1.29	+.23	—25.64	—.0117	—.0110
+3.5	+190.36	+2231.84	+2253.69	— .84	—19.25	—1.93	+.17	—21.85	—.0098	—.0094
+4.0	+206.20	+2262.11	+2279.98	— .58	—15.05	—2.22	—.02	—17.87	—.0079	—.0077
+4.5	+222.04	+2282.09	+2296.23	— .40	—11.36	—2.23	—.15	—14.14	—.0062	—.0061
+5.0	+237.89	+2295.27	+2306.20	— .27	— 8.35	—2.07	—.25	—10.93	—.0048	—.0047

A comparison of the evaluation of the mean curve and the mean-constant curve shows that the difference between them is due almost entirely to the second correction term. This correction term is positive when z is negative, crosses the axis near the origin, which is the z coordinate of the point of inflection of the mean-constant curve, and is negative for positive values of z. It approaches the z axis as a limit, for large values of z, both positive and negative. It has one maximum and one minimum, which occur in the neighborhood of $z = -2.5$ and $+2.5$ respectively. This correction term is not symmetrical, the ordinates for positive values of z being approximately twice as great as the ordinates for corresponding negative values of z.

The effect of this correction term will be, therefore, to raise the mean-constant curve for negative values of z and to lower it for positive values of z, leaving it almost unchanged near $z = 0$. The curve will be lowered on the positive side about twice as much as it is raised on the negative side, the greatest change in each case being near $z = \pm 2.5$ respectively. The mean curve that is thus produced is like the individual curves in that it has only one major cycle, but it has the essential difference that it is a skew and not a symmetrical curve.

For the present illustration, Table 5 shows the size of the difference between the mean curve and the mean-constant curve in absolute grams and in proportion to the mean curve and to K. The maximum difference in the early part of the curve is nearly 14 grams and is between 7 and 8 per cent of the mean curve. In this part of the curve a difference of 14 grams represents a difference of 2 or 3 days growth. In the later part of the curve the maximum difference is about 23 grams and represents 4 or 5 days growth. There is thus a very definite difference between the mean curve and the mean-constant curve, and the mean curve cannot be said to follow the type of growth of the individual curves.

The deviation of the mean curve from a true logistic is shown further in comparing the mean curve with the logistic obtained by Reed's and Pearl's summation theory. The equation for this curve, determined by (21) in the preceding section, is

$$y = \frac{2321.74}{1 + e^{2.3626 - .02945x}}$$

and is evaluated in column (3), Table 6. The deviations of this curve from the mean curve are less in the early and late parts of the range than those of the mean-constant curve. Since it is symmetrical, how-

ever, and agrees well with the mean curve in these parts of the range it must necessarily diverge from it in intermediate positions. The deviations in the neighborhood of —2.5 are about the same size as those of the mean-constant curve from the mean curve. After the point of inflection, the curve diverges more rapidly from the mean curve, having its greatest deviation of about 25 grams near $z = 1$. It is interesting to note that the direction of most of the deviations is opposite in sign to those for the mean-constant curve. The mean curve therefore falls between these two approximations to it, over most of the range. These three curves are shown graphically in Figure 8.

TABLE 6

The Mean of the Individual Rabbit Curves Compared with Three Centering Logistics

z (TIME IN UNITS OF $\frac{1}{b}$ FROM $-\frac{\bar{a}}{b}$)	x (TIME IN DAYS FROM BIRTH)	(1) MEAN OF LOGISTICS (CORRECT TO FIVE TERMS)	(2) MEAN-CONSTANT LOGISTIC	(3) MEAN LOGISTIC BY REED-PEARL METHOD	(4) LOGISTIC FITTED TO MEANS
—5.0	— 79.0	+ 21.9	+ 15.5	+ 21.2	+ 14.0
—4.5	— 63.1	+ 33.5	+ 25.5	+ 33.6	+ 23.2
—4.0	— 47.3	+ 51.6	+ 41.8	+ 53.1	+ 38.4
—3.5	— 31.4	+ 79.7	+ 68.1	+ 83.5	+ 63.1
—3.0	— 15.6	+ 123.1	+ 110.1	+ 130.4	+ 102.9
—2.5	+ .3	+ 189.8	+ 176.1	+ 201.2	+ 166.2
—2.0	+ 16.1	+ 289.8	+ 276.8	+ 305.1	+ 263.7
—1.5	+ 31.9	+ 434.7	+ 423.6	+ 451.2	+ 407.7
—1.0	+ 47.8	+ 632.7	+ 624.4	+ 644.9	+ 606.9
—0.5	+ 63.6	+ 880.4	+ 876.6	+ 882.5	+ 859.9
0.0	+ 79.5	+1159.8	+1160.9	+1147.8	+1147.5
+0.5	+ 95.3	+1436.3	+1445.2	+1414.4	+1436.8
+1.0	+111.2	+1679.6	+1697.3	+1655.6	+1693.6
+1.5	+127.0	+1873.4	+1898.2	+1853.9	+1897.7
+2.0	+142.8	+2016.7	+2045.0	+2004.5	+2046.1
+2.5	+158.7	+2117.4	+2145.6	+2112.1	+2147.0
+3.0	+174.5	+2186.0	+2211.6	+2185.7	+2212.8
+3.5	+190.4	+2231.8	+2253.7	+2234.5	+2254.3
+4.0	+206.2	+2262.1	+2280.0	+2266.2	+2280.0
+4.5	+222.0	+2282.1	+2296.2	+2286.6	+2295.8
+5.0	+237.9	+2295.3	+2306.2	+2299.6	+2305.4

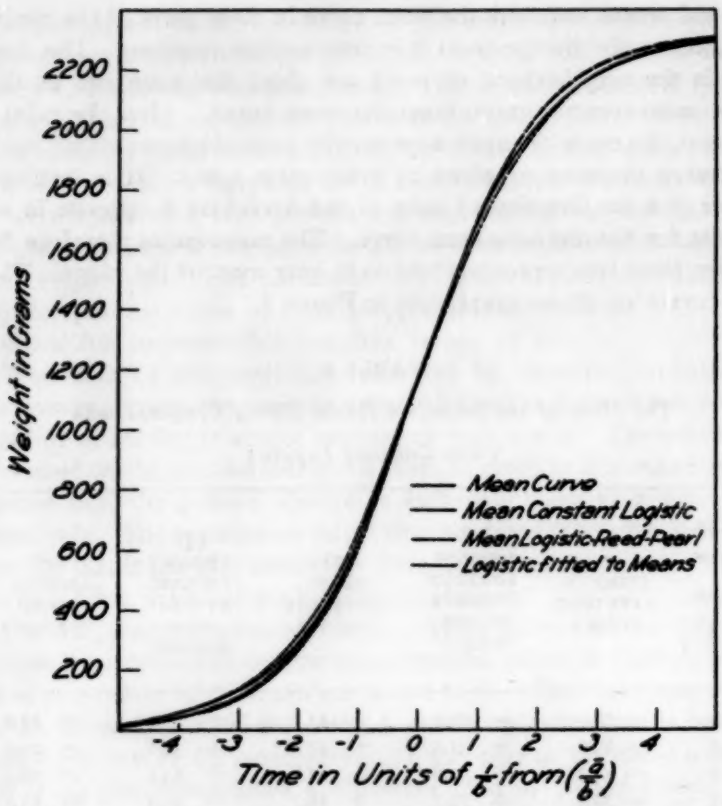


FIG. 8. MEAN OF LOGISTICS FITTED TO INDIVIDUAL RABBIT WEIGHTS, COMPARED WITH THREE CENTERING LOGISTICS

The two logistics just considered as approximations to the mean were obtained by knowing the constants of the individual curves. In actual practice, knowledge of the individual growth is usually lacking. The observations ordinarily are taken on individuals of various ages which are grouped into successive age bands, the average of the observations for each group is formed, and the description of growth changes is given in terms of these averages. In the present illustration it is possible to carry out this procedure and compare the result with the mean curve which is formed from the individual growth curves.

The averages of the weights in this series of observations were formed by weekly periods from the age of four weeks to fifteen weeks, by two-week periods from fifteen weeks to twenty-three weeks and for a

four-week period from twenty-three to twenty-seven weeks. The reason for taking broader age bands in the older ages was that the observations were taken less frequently in this period and consequently the number of observations in a weekly period was too small to give a stable average.

A logistic curve was fitted to these averages by the same method as that used for fitting the individual curves, described above. K was determined to the nearest hundredth of a kilogram. In determining K, values of 2300, 2310, 2320 and 2330 grams were tried. The plot on arithlog paper of $\frac{K-y}{y}$ against x, showed the first two values to be too low. The last two values gave plots very close to a straight line and since it was difficult to decide between them, logistics were fitted for both cases, and the standard deviation of the observations about each curve was computed. Since the standard deviation was slightly lower for the K of 2320 grams, this curve was used. The observed and theoretical values for this curve are given in Table 7. The standard deviation of the points about the curve is 26.3 grams. Figure 9 shows graphically the fit of the curve to the observations.

TABLE 7

Mean Weights of Rabbits and Calculated Values from Logistic Fitted to Means

x (TIME IN DAYS FROM BIRTH)	OBSERVED	CALCULATED
28-34	392.7	403.0
35-41	504.8	483.3
42-48	584.4	574.8
49-55	673.7	677.2
56-62	774.9	789.6
63-69	910.5	910.4
70-76	1037.3	1037.1
77-83	1183.2	1166.8
84-90	1298.8	1296.4
91-97	1459.7	1422.6
98-104	1535.4	1542.6
105-118	1736.1	1706.0
119-132	1822.7	1886.6
133-146	1989.6	2023.3
147-160	2114.0	2121.5
161-188	2230.3	2214.3

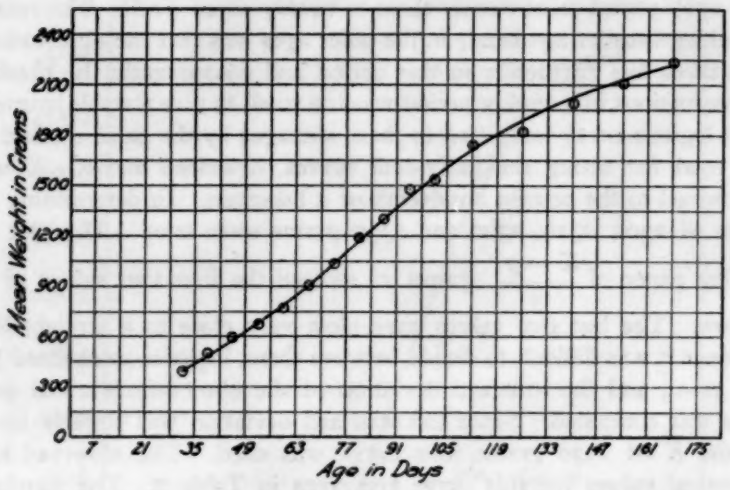


FIG. 9. LOGISTIC FITTED TO MEANS OF OBSERVED RABBIT WEIGHTS

The constants of this curve, in comparison with the two central logistics previously discussed, are as follows:

	K	a	b
Logistic fitted to means	2320	2.5699	—.03207
Mean-constant logistic	2321.7	2.5080	—.03156
Mean logistic (Reed and Pearl)	2321.7	2.3626	—.02945

The evaluation of the logistic fitted to the means is given in comparison with the mean curve in column (4) of Table 6. This logistic undershoots the mean curve for negative values of z more than the mean-constant curve does, and overshoots it in the positive part of the range by about the same amount as the mean-constant curve. It is thus a less accurate approximation to the mean curve in this case than either of the other logistics considered. The discrepancy between the mean curve and the curve fitted to the means is due to the grouping of measurements into an age band of some arbitrary size. For this reason, the ordinary process of describing the growth by a curve fitted to the means of the observations will not necessarily lead to the mean of the individual growth curves.

The application of the expression for the mean of a group of logistics to this series of individual curves shows that for a cluster of logistics having variability and correlation of this type, the mean curve agrees

with the individual curves as to its number of important cycles. The mean curve does, however, differ definitely in type from the individuals since the effect of the second correction term is to introduce a skewness into the mean curve which is absent in the individuals.

For a group of individuals which are more highly variable than the curves in this illustration, the correction terms higher than the second will become important and the mean curve may have a greater number of significant fluctuations than the individuals. Since the variability and correlations in the rabbit growth material are, however, of the same general character as those observed in other biological material, this illustration can probably be considered representative. It is therefore reasonably safe to assume that the principal epochs observed in the growth of averages of individuals do not arise from the averaging process but are present also in the individual growth. It is not, however, safe to ascribe to the individuals the degree of symmetry observed in the averages, since the averaging process produces a mean curve different in this characteristic from the individual curves from which the mean is formed.

Since the logistic curve is used widely to express growth of population as well as growth of individual organisms, it is of interest to see the effect of applying this theory to the summation of population curves. It has been shown that it is the variability of the a and b constants which determines the extent of the differences in the characteristics of the average or total curve and the individual curves. The variation in a measures essentially the variation in the proportion of the limiting growth attained at a particular time. Since in practice, curves would not be summed that differed fundamentally as to the stage they had reached in their growth, the variability of a will be small. In order to get some estimate as to the variability of the b or rate constant in such problems, the coefficient of variation was computed for the fifteen countries whose curves are given by Pearl.[14] This coefficient is 27 per cent, as compared with a coefficient of 18 per cent for the b constants of the individual curves of the preceding illustration. In view of the fact that these fifteen countries are scattered over all the world and represent very diverse types of civilization, it is probable that the variability in this group is considerably greater than would occur in a group of populations which would be put together in any actual problem. The size of the deviation of the mean curve from a simple logistic in the application to the group of individual curves given above is probably fairly representa-

tive, therefore, of the deviation which would be likely to be met in summing population curves.

SUMMARY

This study treats of the relationship between the form of individual growth curves and their average. The average of a group of individual curves of any given function is expressed in terms of the mean-constant curve and a series of correction terms involving the partial derivatives of the function with respect to the constants and the moments of the constants.

This theory is applied to two empirical growth equations—the generalized parabola and the logistic. For the parabola the correction terms vanish and the mean curve is identical with the mean-constant curve. For the logistic the correction terms persist as a power series in σ^2_{a+bx}, whose coefficients contain successive derivatives of the logistic with respect to a. The form of the mean curve differs from the simple logistic in two fundamental characteristics,—it is a sinuous curve having fluctuations in its rate of growth not present in the logistic, and it is not a symmetrical curve.

The equation for the mean of a group of logistics is applied to a series of individual growth observations which are fitted with logistic curves. It is found that for curves having the type of variation present in this group of observations, only the second correction term is important. The effect of this term is to raise the early part of the mean-constant curve and lower the later part, the latter correction being about twice as large as the former. The introduction of this skewness is the principal effect of the correction terms since the fluctuations in the rate of growth which are inherent in the mean curve equation are insignificant for material of this degree of variability.

These results lead to the following general conclusions:

The average of a series of individual growth curves may differ in certain fundamental characteristics from the separate curves. Therefore when observations on any biological form are taken on different individuals of varying ages and the description of growth is given in terms of the averages of these observations, the form of the growth of these averages cannot be assumed to be characteristic of the growth of the individual organism. The curves may differ as to the number of major cycles in their growth and as to the degree of skewness.

The extent of these differences depends upon the variability of the individuals. In cases of extreme variability, significant undulations may

be present in the average, which are entirely lacking in the individual growth. To interpret these variations as epochs in the growth of the individual organism, associating them with physiological age changes, would be fallacious, since they are a result of the mathematical process of averaging and have nothing to do with the biology of growth. With the variability ordinarily met with in biological material, which is illustrated in the numerical example given in this paper, these additional fluctuations are insignificant in size. Consequently it is safe to say that the fluctuations in rate frequently observed in the growth of averaged observations do not arise merely from the averaging process, but are present also in the individuals.

A much more pronounced effect produced by averaging is in changing the degree of skewness in the mean curve. For the type of variability illustrated in this paper, the mean curve differs definitely from the individuals in this characteristic, and in more variable material, the difference is much more marked. It is therefore not possible to ascribe the degree of asymmetry observed in a series of averaged measurements to the growth of an individual organism.

Since the result of averaging symmetrical logistics is to produce a skew mean curve, the question arises as to the effect of the averaging process on skew individual curves. This question is not treated specifically in this study but the direction of the corrections for the logistic suggests that the mean of skew growth curves is more symmetrical than the individual curves.

This analysis shows, therefore, that the number of significant cycles in a growth curve is fairly stable and is maintained unchanged in the average curve except when there is a high degree of variability in the curves, but the degree of skewness is a more sensitive characteristic which does not persist unchanged through the process of averaging individual curves.

REFERENCES CITED

1. Scammon, R. E., and Calkins, L. A. (1929) The development and growth of the external dimensions of the human body in the fetal period. The University of Minnesota Press, *Minneapolis.*
2. Murray, H. A. (1925) Physiological ontogeny. *Jour. Gen. Physiol.*, vol. 9, 39.
3. Pearl, R., and Reed, L. J. (1925) Skew-growth curves. *Proc. Nat. Acad. Sci.*, vol. 11, 16.
4. Gray, J. (1929) The kinetics of growth. *Brit. Jour. Exp. Biol.*, vol. 6, 243.
5. Robertson, T. B. (1923) The chemical basis of growth and senescence.

J. B. Lippincott Company, *Philadelphia* and *London*.

6. Brody, S. (1927) Growth and development. Research Bull. 97, Agricultural Experiment Station, University of Missouri.
7. Pearl, R., and Reed, L. J. (1920) On the rate of growth of the population of the United States since 1790 and its mathematical representation. *Proc. Nat. Acad. Sci.*, vol. 6, 278.
8. Holt, L. E. (1918) Standards for growth and nutrition. *Amer. Jour. Dis. Child.*, vol. 16, 359.
9. Yule, G. U. (1925) The growth of population and the factors which control it. *Jour. Roy. Stat. Soc.*, vol. 88, 1.
10. Reed, L. J., and Pearl, R. (1927) On the summation of logistic curves. *Jour. Roy. Stat. Soc.*, vol. 90, 729.
11. Castle, W. E. (1922) Genetic studies of rabbits and rats. Carnegie Institute of Washington, Pub. 320.
12. Pearson, K. (1900) On the magnitude of certain coefficients of correlation in man. *Proc. Roy. Soc.*, vol. 66, 23.
13. Berkson, J. (1929) Growth changes in physical correlation. Human Biology, vol. 1, 462.
14. Pearl, R. (1924) Studies in human biology. Williams and Wilkins Co., *Baltimore*.

DIFFERENTIAL MORTALITY IN THE AMERICAN NEGRO

BY S. J. HOLMES

Where two or more races occupy the same territory each race tends to supplant its rivals. Whether the races engage in actual conflict or live together on the most peaceable and friendly terms the biological struggle for supremacy inevitably goes on. Barring migration and the possible absorption of one race by the other, the race which maintains the greatest excess of births over deaths will necessarily prevail over its competitors. Even if our white and negro inhabitants should ultimately become fused into a single hybrid stock, the relative net fertility of the two races would, in the meantime, have a marked influence on the complexion of the resulting product.

Both the birth rate and the death rate of American negroes have undergone marked changes since the period of emancipation. The wretched conditions under which negroes were compelled to live after their liberation from slavery led to an appalling increase of mortality. Tuberculosis, venereal diseases and other infections rapidly spread, and infant mortality rates were commonly between 200 and 300 per 1,000 births. To judge from our imperfect vital statistics for this period negro mortality for some decades after the Civil War was on the increase, and it apparently reached its height in most localities sometime in the eighties. Nevertheless it was during this period of very high mortality that the negroes showed the most rapid natural increase. For several decades both the birth rate and the death rate have been falling in our colored population and the rate of natural increase has been slowly decreasing. A similar decrease of births and deaths has been taking place in the whites, but while both the birth rate and the death rate are lower in the whites than in the negroes our white population continues to show the more rapid growth.

In this paper we are concerned with but one aspect of the interracial struggle. The course of the negro birth rate in different areas of the United States will be considered in a later communication. If the negroes had as low a mortality as the whites they would now be

multiplying at the more rapid rate. The marked reduction of negro mortality which has occurred during the past three decades has led several writers to infer that the differences in the death rates of negroes and whites are the product of environmental causes and hence may ultimately be obliterated. We may concede without further discussion that a large part of the high mortality of the negro is a direct consequence of ignorance and unfavorable surroundings. This is true to an even greater degree for the death rate of infants than it is for that of adults. In the case of several diseases it is impossible to separate, even with the rudest approximation, the effects of environment from those of racial heredity. The relatively high death rate of the negro from typhoid fever, malaria and dysentery may be wholly accounted for, so far as is positively known, by the negro's insanitary mode of life and the accidents of his geographical environment. But to argue from facts of this kind that racial differences are negligible factors in mortality is to commit a serious, though very common error.

The advantages of more favorable surroundings are everywhere enjoyed by the whites. Consequently, where we find that, in spite of this fact, there are certain diseases that are considerably less fatal to the negro we are more justified in attributing this advantage to a racial idiosyncrasy. There are several diseases of this sort, such as scarlet fever, erysipelas and diphtheria. On the other hand, the negro is especially attacked by several diseases whose ravages, although aggravated by unfavorable surroundings, nevertheless furnish evidence of being determined to a large extent by hereditary factors.

The subject of differential mortality is full of pitfalls. One source of confusion is the failure to distinguish between a true racial immunity to a disease and an immunity slowly built up through the direct reaction of persons exposed to infection. Much has been learned about the acquisition of immunity which was quite unknown three decades ago, and this knowledge has an important bearing on several matters affecting the welfare of the colored population. Different diseases present their peculiar problems, and these will be discussed in the sections devoted to particular maladies.

SCARLET FEVER

The negro race has long enjoyed a partial immunity to scarlet fever. Deaths under one year are not very numerous, but since 1914 there have been nearly four times as many among the whites as among the colored in proportion to the number of infants of these races. In older

age periods the racial difference becomes more pronounced. From 1919 to 1923 inclusive, there have been in the Registration States 785 deaths of whites and 35 of colored children under one year from scarlet fever, giving a ratio of 23.43 white to 1 colored infant. In the same area and period there have been 8,095 deaths of white children and 137 deaths of colored children under 5 years, giving a ratio of 69.09 whites to 1 colored. Both of these figures are several times the expected ratio for all deaths which for these years would lie between 5 and 6.

In his valuable survey of the vital statistics of the census of 1890 Dr. J. S. Billings states that the death rate for scarlet fever "was much higher among the whites (14.20) than it was among the colored (2.72)." In a similar survey of the vital statistics of the census of 1880 Dr. Billings remarks that scarlet fever "caused a much greater proportion of the deaths among the whites (20.9) than among the colored (3.9)." For a group of 28 cities in 1890 the death rate for whites was 17.81 and for the colored, 3.84. Deaths from scarlet fever were not given for infants under 1 year in the 1890 returns, but the data collected for 31 cities showed 240 deaths among whites and 3 among negro infants, while in children under 5 there were 2,511 deaths among whites and 31 among negroes. The total deaths under 1 year in these same cities were in the ratio of 7.6 white to 1 colored, and under 5 years in the ratio of 8.45 white to 1 colored.

Statistics of the census of 1870 show 20,011 deaths from scarlet fever among whites and 289 among negroes, giving a ratio of 69.24 to 1, as compared with the ratio of 6.27 for deaths from all causes. Before this we do not have comparative statistics over any extensive area. In 1870 deaths of whites from scarlet fever were over ten times as prevalent as among blacks on the basis of the general death-rates of the two races. A certain amount of allowance should be made, however, on account of the inaccuracies in the returns of the 1870 census for the negro population.

In this connection we may cite the experience of the Metropolitan Life Insurance Company which insures large numbers of children among both whites and negroes, although it does not take children under one year of age. The results are summarized in the following table, which gives the death-rates of white and colored policy holders from 1911 to 1916 based on 4,638 deaths.

TABLE 1

Mortality from Scarlet Fever of White and Colored Policy Holders in the Metropolitan Life Insurance Company 1911-1916. Rates per 100,000 Persons Insured

AGE	WHITE		COLORED	
	Males	Females	Males	Females
All ages over one year	10.6	8.6	2.5	2.2
1-4	53.5	48.8	16.0	22.2
5-9	24.3	23.4	8.8	6.4
10-14	5.8	7.5	5.1	2.5
15-19	3.0	2.9	1.0	2.3
20-24	1.2	2.2	—	.5
25 and over	.4	.6	.2	.3

A comparison of the death rates of white and colored persons in individual years showed that the death rates of both sexes were much greater for whites than for colored persons in each of the six years covered by the returns. The subsequent experience for the same company shows much the same relation between the death rates of its white and colored patrons.

In studying the racial incidence of a disease one must guard against sources of error due to the peculiar features of its geographical distribution. Scarlet fever is less prevalent in the Southern States than in the North, as is very clearly shown in Dr. Billings' maps of the regional distribution of this disease. This low death rate from scarlet fever as Dr. Billings remarks, may be due in part to the large negro population of the Southern States. One may obviate sources of error due to geographical distribution by comparing the deaths of white and colored persons in restricted areas. In the following table (Table 2) are given the death rates of the white and colored population per 100,000 members of these groups in the states of the Registration Area which report deaths by race. It will be seen that there is a wide fluctuation, not only in the death rate from scarlet fever in different times and places, but also in the relative death rates of the white and colored population. This latter circumstance is mainly due to the small number of cases reported and the consequent influence of chance variations. Occasionally the rate for the colored people exceeds that of the whites, but it is never twice as great, and in no state of the Area does it consistently exceed that of the whites. In some of the states the rate for the whites is often over three times that of the colored. In contrast with the rates for the Southern

TABLE 2

Death Rates per 100,000 from Scarlet Fever for White and Colored Population in Several States

		1927	1926	1925	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1914
Fla.	W	1.2	1.6	0.6	0.4	0.6	0.7	1.5	1.4	0.6					
	C	0.2	0.2	0.0	0.0	0.9	0.3	0.3	0.0	0.0					
Ga.	W				1.0	1.0	1.4								
	C				0.2	0.4	0.3								
Ky.	W	2.0	2.4	2.1	1.4	2.2	1.9	2.8	2.7	2.3	2.2	2.3	2.5	2.5	2.8
	C	0.9	0.9	0.9	1.3	0.4	0.9	1.3	0.9	0.8	0.4	0.4	0.8	1.2	1.6
La.	W	0.7	0.7	0.8	0.5	0.5	0.5	0.9	1.3	0.4	0.5				
	C	0.3	0.4	0.0	0.1	0.1		0.1	0.1	0.1					
Md.	W	1.2	1.5	1.2	3.2	3.7	2.5	2.2	3.0	4.6	1.9	1.9	4.2	5.7	6.0
	C	0.3	0.4	0.0	1.6	1.2	1.2	1.6		0.8	0.8	0.8	1.7	2.5	3.4
Miss.	W	2.0	0.6	0.8	1.2	1.2	0.7	0.9	1.9	0.7					
	C	.0	0.1	0.4	0.1	0.3		0.9	0.9	0.7					
N. C.	W	1.6	1.4	1.4	1.8	1.4	3.7	2.2	2.1	1.2	1.3	2.2	3.4	2.5	0.6
	C	0.1	0.7	0.2	0.2	0.5	1.1	0.6	0.3	0.4	0.4	0.5	0.5		0.6
S. C.	W	0.6	0.9	0.8	0.3	0.7	1.5	1.5	0.8	0.7	1.0	1.7	3.9		
	C	0.1	0.3	0.0	0.1	0.1	0.6		0.5	0.5		0.9	1.1		
Tenn.	W	2.4	1.9	1.4	1.5	1.5	2.2	2.0	2.5	2.8	2.4	2.5			
	C	0.2	0.9	1.4	0.7	1.6		0.7	1.3	0.7		0.7			
Va.	W	1.5	1.7	2.0	1.7	2.5	2.0	3.3	1.7	1.9	1.4	1.0	1.8	1.4	2.6
	C	0.3	0.1	0.8	0.4	0.3	0.4	0.7	0.7	0.4	0.3	0.3	0.3	0.4	
D. of C.	W	1.0	1.2	1.0	2.2	3.3	1.5	2.4	2.4	1.2	5.8	3.3	1.7	2.8	0.4
	C	4.0	2.4	0.8	1.7	2.6		0.9	0.9	-			1.0	1.0	

States, as shown in the table, we may cite the rates for 1923 in several of the Northern States. California 3.2, Colorado 4.2, Connecticut 3.7, Delaware 8.7, Illinois 3.4, Indiana 3, Iowa 5.9, Kansas 4.0, Mississippi 9.3, Michigan 7.8, Massachusetts 4.0, Nebraska 4.4, Pennsylvania 6.4, Wisconsin 8.6.

Taking groups of states we find the rates for whites and colored in 1880 and 1890 as follows:

TABLE 3

Proportions of Deaths from Scarlet Fever in the White and Colored Population as Compared with 1,000 Deaths from Known Causes

REGION	1880		1890	
	White	Colored	White	Colored
North Atlantic Coast Region	...	...	3.94	1.83
Middle Atlantic Coast Region	23.4	5.7	7.63	2.13
South Atlantic Coast Region	2.2	2.1	0.39	0.62
Gulf Coast Region	2.4	1.6	1.38	1.23
Interior Plateau	24.1	6.2	9.19	1.18
South Central Appalachian	11.6	5.7	3.15	1.99
Ohio River Belt	43.8	14.8	5.67	0.32
South Interior Plateau	2.0	0.8	1.91	0.42
South Mississippi River Belt	15.9	4.5	3.26	1.63
Southwest Central Region	9.8	3.4	2.25	1.48
Central Region, Plains and Prairies	23.7	5.3	9.30	1.63
Total	20.9	3.9		

Similar high rates for the whites are shown in several cities. In Baltimore (1905 to 1919) there were 457 deaths among whites and 31 among negroes, giving a fatality according to Howard ('24) "nearly three times greater in the white than in the negro race." Morbidity rates of Baltimore for 1921 show a rate of 164 per 100,000 for whites and 39 for negroes, based on a total of 1,069 cases. The history of scarlet fever in Baltimore, according to Howard, shows that:

> During the last 20 and probably the last 40 years, the morbidity rates have increased as the mortality rates have declined; in other words the capacity of scarlet fever to attack the population has increased as its lethal force has diminished. . . . A very remarkable change has occurred in the ratio of mortality among negroes as compared with whites. In 1850 the mortality rate for the former was only about one-fourth less than that for the latter, while during the past 15 years, the mortality was nearly three times greater among the whites than among negroes.

The data for 1850, however, comprise a total of 225 deaths for both races in a population in which the whites were over five times as numerous as the blacks. A difference of only 10 deaths in the colored population would make a very material difference in the mortality rates of the two races. While scarlet fever, like many other epidemics, varies in virulence in different times and places, I cannot find any adequate evidence of a general change in the way in which it affects the colored population. There seems to be little to cause changes in the diagnosis of scarlet fever, because there has been little improvement in the method of distinguishing this disease from others with which it may be confused.

The experience of the U. S. Army during the World War bears out the preceding conclusions as to the racial incidence of scarlet fever, as may be seen in the following table:

TABLE 4

Admissions, Deaths, Discharges, and Days Lost from Scarlet Fever Among White and Colored Troops in the U. S. Army, April, 1917, to December 31, 1919

	WHITE	COLORED
Admissions—		
Number	10,993	97
Rate per 100,000	3.05	.34
Deaths—		
Number	338	2
Rate per 100,000	.09	.01
Discharges—		
Number	18	0
Rate per 100,000	.01	0
Days Lost—		
Number	472,967	4,639
Rate per 100,000	.36	.04

MEASLES

According to many accounts measles acts with very different degrees of severity upon the various races of mankind. That certain races show an extreme susceptibility to measles is due in large part to the fact that they have built up no immunity against this disease. True racial differences in susceptibility probably exist, but they are more difficult to demonstrate than has commonly been assumed. The complications of the problem will become apparent in the discussion which follows.

During the first year of life the death rate from measles is relatively low, and of the deaths which occur the great majority fall within the last six months. A compilation of deaths from measles occurring in the Registration Area for Deaths from 1914 to 1923 shows that the death rate among negro infants is only about two-thirds as high as would be expected on the basis of total deaths. The ratio of deaths (colored to white) is 1 to 10.94 instead of 1 to 7.47, the ratio of infant deaths for all causes combined. The data are sufficiently extensive and extend over a sufficient period of time to eliminate the influence of the great

annual and regional differences which are so apt to betray one in interpreting the statistics of this disease.

Since 1920 death rates both crude and adjusted have been published in the U. S. Mortality Statistics for the Registration States of 1920 and these show that, except during two years, 1923 and 1924, the whites suffered more from measles than the colored population. These rates are given in the following table:

TABLE 5

Death Rates, Crude and Adjusted, from Measles in the United States Registration States of 1920 (1920-1927)

	WHITE		COLORED	
	Adjusted	Crude	Adjusted	Crude
1920	9.9	9.3	4.3	4.1
1921	4.6	4.3	3.6	3.4
1922	5.0	4.7	3.2	3.0
1923	11.2	10.5	16.8	15.7
1924	7.7	7.2	16.2	15.1
1925	2.6	2.5	2.0	2.0
1926	9.3	8.7	6.4	6.2
1927	3.9	3.7	5.7	5.5

One meets with considerable variation in the relations between the rates for the white and colored population from year to year as well as marked fluctuations in the general death rate from this disease. The more or less periodic epidemics which sweep over large sections of the country may prevail now in the north and now in the south, or again in the west. Since the proportion of colored people varies enormously in different parts of the Registration Area we would naturally have a high death rate for the colored population when measles prevailed in the south, and a relatively low rate when it prevailed in the north or west. Inasmuch as measles seems to thrive in all climates, these variations would tend to cancel out in data covering a series of years. In 1923 and 1924 there was not only a high death rate from measles in the Registration States, but the death rate for the colored population rose above that of the whites, whereas in the five preceding years the death rate for the whites exceeded that for the colored.

The clue to the exceptionally high rate for the colored population in 1923 and 1924 is found in the fact that the general measles rate increased very greatly in several of the southern states. According to the volume on Mortality Statistics for 1923, "Comparing the rates for 1922

and 1923 for the 37 Registration States shown for both years, increases in 1923 are shown for 32 states, the largest increases appearing for Delaware (from 1.8 to 25.2), Rhode Island (from 0.8 to 21.8), North Carolina (from 0.9 to 21.9) and Virginia (from 1.5 to 22.3)." In one other year, 1917, the general mortality from measles in the Registration Area was higher in the negroes than in the whites and this was also a year in which measles was very prevalent in the southern states.

In commenting on the measles rates for 1916 and 1917 the report on Mortality Statistics (1917) makes the following statement: "Comparing the Registration States for 1917 and 1916, decreases are shown for 1917 by 11,—Connecticut, Massachusetts, Michigan, Minnesota, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Virginia, and Wisconsin,—while 4,—Kentucky, Maine, North Carolina, and South Carolina show rates in 1917 more than five times those of 1916." In all of the last mentioned states except Maine, in which the negro rate was based on less than five cases, the white rate exceeded that for the colored. A higher rate for whites is shown in some other southern states, but not in all, for the same year.

It is one of the seeming paradoxes such as are often found in vital statistics, that the addition of areas in each of which the white death rate for a particular disease is greater than the negro rate may give for the region as a whole a death-rate which is higher for negroes than for whites. Failure to be on one's guard against this possibility is very apt to lead to error in the interpretation of statistical data. This source of error is especially apt to betray one in the problems with which we are dealing. One of the best ways of avoiding the statistical pitfalls due to the uneven geographical distribution of a disease is to study the death rates in particular localities over a series of years. We, therefore, submit the following data on the course of mortality from measles during several years in a number of states. In general it may be seen that the mortality rate of the negro is usually less than that for the whites.

There are, however, several cases in which the death rate among the colored exceeds that of the white population. These may sometimes be due to chance fluctuations in cases where there were only a small number of deaths but the preponderance of negro deaths in some states in 1923-24 is probably due to other causes. During the year of greatest mortality from measles (1917) the rate for whites exceeded that for the colored in all states listed in the preceding table, except Maryland, and in this state the measles rate was the lowest of all in the states recorded.

TABLE 6

Death Rates from Measles per 100,000 Population—White and Colored in Selected States, 1915-1927

		1927	1926	1925	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915
Fla.	W	1.6	2.1	0.8	20.8	9.2		0.9	1.7	6.5				
	C	1.6	2.2	0.5	20.0	10.7	0.6	0.6	0.6	3.3				
Ga.	W				20.3	15.4	0.1							
	C				16.1	8.7	0.4							
Ky.	W	6.0	19.3	1.4	12.5	17.2	4.3	7.9	11.8	10.2	18.5	41.5	8.4	3.8
	C	4.3	11.7	1.8	4.0	13.7	6.5	1.7	5.1	6.3	6.2	29.7	4.1	1.6
La.	W	13.3	0.2	0.4	22.2	8.2	1.0	7.3	3.1	2.5	21.5			
	C	14.5	1.0	0.7	30.2	5.0	0.6	4.1	1.3	1.7	16.9			
Md.	W	1.1	13.7	1.8	3.3	10.1	4.8	3.3	6.8	3.5	10.6	8.0	7.9	2.2
	C	2.3	15.3	0.4	4.8	11.2	7.3	2.4	4.9	2.0	13.6	10.8	7.1	3.8
Miss.	W	14.1	5.6	2.1	15.5	9.8	0.4	2.0	0.6	3.1				
	C	6.0	2.2	0.5	7.5	15.5	0.7	1.2	1.4	1.7				
N. C.	W	9.3	2.6	0.6	17.1	20.8	0.6	6.3	2.8	6.6	17.6	45.9	6.9	0.9
	C	6.5	5.2	0.5	16.0	24.5	1.6	4.1	1.4	1.2	6.9	33.9	7.6	
S. C.	W	7.9	0.7	0.2	32.2	12.8	0.2	6.9	4.2	3.2	22.1	53.2	4.8	
	C	3.1	0.6	0.4	29.8	11.3	0.7	3.4	2.4	3.2	20.6	28.6	4.4	
Tenn.	W	6.5	13.0	2.4	13.1	21.7	0.6	3.7	12.3	8.0	19.8	35.2		
	C	3.5	8.3	2.5	10.4	22.3	2.0	2.2	3.5	3.3	8.3	29.3		
Va.	W	4.6	4.3	2.7	8.1	23.5	1.9	7.9	4.2	3.8	15.8	17.3	16.2	2.5
	C	4.4	3.1	3.9	10.9	19.5	0.4	6.5	3.6	1.9	9.6	12.0	23.1	2.9

However, when we study the comparative death rates of the white and colored population in individual states we do not avoid all the errors due to differences in geographical distribution. Death rates from measles are usually higher in cities than in rural districts. The proportion of whites and negroes is usually much different in cities from what it is in the country. In several of the southern states with the largest colored population negroes are predominantly rural in distribution. In the north and west they are largely concentrated in cities.

A study of the relative death rates of the races in cities affords a means of avoiding errors due to the cause just mentioned, but at the same time it introduces the chance of falling into others. One circumstance to be considered is the relative proportion of children to that of older persons in the two races, since the race with the largest proportion of children is apt, other things being equal, to have the higher death rate from measles. A large part of our data on the death rates of the

white and colored population of cities is confined to the last 10 or 12 years. During this time, owing to circumstances connected with the Great War, there has been a great stimulus to the urban migration of negroes, and this migration has affected the negro population of different cities in a very unequal manner. Estimates of the negro population which have been made year by year are very apt to be quite different from the true number. I strongly suspect that this circumstance has contributed not a little to cause the variations in negro death rates which the statistics of our cities exhibit. The same factor of recent migration would affect greatly the proportion of negro children in different cities.

Formerly the opinion was frequently expressed that measles is more fatal to negroes than to whites. Dr. E. R. Corson in his extensive paper on "The Vital Equation of the Colored Race," after remarking that diphtheria and scarlet fever are less common among the colored people, states that "measles and whooping cough are both very much more fatal among them." This conclusion is supported by the data contained in the reports of the U. S. Census for 1870, 1880 and 1890. In 1870 there were reported 2,059 deaths from measles among negroes and 7,158 among whites. This gives a death rate of 30 per thousand of total deaths for negroes and 16.8 per thousand of total deaths for the white population. In 1880 the proportion of deaths from measles to one thousand deaths from all causes was 12.12 for whites and 23.75 for negroes. While the measles rate was relatively high in the southern states in 1880, we find that the rates in the several regions were higher for negroes than for whites. Taking the areas in which the rates for the two races are given we have the following:

TABLE 7

Death Rates from Measles per 1,000 Deaths from all Causes in the White and Colored Population, 1880

	WHITE	COLORED
Middle Atlantic Coast Region	6.3	8.3
South Atlantic Coast Region	14.0	22.6
Gulf Coast Region	7.1	9.4
Interior Plateau	6.5	18.3
South Central Appalachian Region	9.4	21.5
Ohio River Belt	9.9	15.4
South Interior Plateau	11.0	26.7
South Mississippi River Belt	4.4	7.7
Southwestern Central Belt	16.7	14.4
Central Region Plains and Prairies	11.0	10.4
Total	9.1	17.7

With the exception of the last two areas in which the excess of white deaths from measles is not great the data show a rather striking preponderance of deaths in the colored population. It should be borne in mind that the returns of the deaths of the censuses of 1870, 1880 and 1890 were very incomplete. It was estimated that something over 40 per cent of the deaths were not returned in the census of 1870, and Dr. Billings considers that a high percentage of deaths were not recorded in the censuses of the two following decades. The data have a certain value, however, for purposes of comparison, although it is probable that negro deaths were reported less frequently than those of whites. Under the circumstances it is more accurate to use the proportion of deaths from a particular disease to total deaths, as is done in the table, than it is to employ deaths per thousand of the population, which give too low a rate of mortality. For the entire United States the proportion of deaths from measles to 1,000 total deaths in 1890 was 10.45 for whites and 14.87 for negroes. The data from the Registration Area for that period show a death rate per 100,000 inhabitants of 13.23 for whites and 19.58 for the colored. At the next census (1900) the death rates from measles in the white and colored races were not so far apart. The rates in the Registration Area per 100,000 population were 13.1 for the whites and 15.02 for the colored. Death rates of infants under one year, however, were 150.0 per 100,000 population for the white, and 219.6 for the colored population.

Taken at their face value the data here presented point to the conclusion that measles is coming to act with decreasing severity upon the colored population. But statistics, and especially vital statistics, cannot always be taken at their face value. There are in fact several sources of error which we should consider before we are justified in having confidence in the conclusion just stated. There is the source of error already alluded to, arising from the uneven geographical distribution of the disease. So far as the later data on measles are concerned we have been able to make fairly adequate allowance for this factor. The less complete data for earlier decades do not permit us to do this so well, but the probabilities are that this disturbing factor does not account for the observed result.

There is the matter of the different age composition of the two races and the changes which the races have undergone in this respect during the past few decades. We should naturally expect a race with a large proportion of children under five years to have a high death rate from

measles. But measles is a children's disease because most adults are already protected by having had it while young. Aside from this circumstance the disease pays little attention to age. Where two races are commingled, the one which has reduced its birth rate the more rapidly would have relatively fewer susceptibles and would hence show a lower rate for this disease. In large sections of our country, but by no means in all, this is the condition we have presented. This is indicated in several of the southern states by the fact that the proportion of children under five has decreased more rapidly in the negroes than in the whites. In the north the proportion of children under five among the negroes is very much less than it is in the south. It is a significant fact that when we consider only deaths under one year of age we find the same excess for whites as we do in more advanced age groups. In table 26 it may be seen that this excess occurs in all years except 1917, 1923, and 1924, which are the years of negro excess for the general population. The data for the age groups given for 1920, 1921, 1922, and 1923 show that the white excess is found (except in 1923) for each age group up to the adolescent period when the numbers become too small to be significant. The same conclusion is borne out by the statistics of the Metropolitan Life Insurance Company. It is quite evident that differences in age composition can explain only a part of the racial incidence of the death rate from measles.

A factor of possibly considerable influence is changes in habits of reporting causes of death. In measles and other diseases affecting infancy and childhood, the original infection may afford the occasion for an attack of pneumonia or some other fatal malady, and the question may arise as to whether the death should be recorded as due to the original disease or the secondary complication. In general, physicians report the final complication as a cause of death less frequently than formerly. Negroes are especially prone to succumb to the respiratory sequelae which commonly follow children's diseases. Consequently changing customs of reporting deaths might not only make changes in the death rates for children's diseases, but also changes in the relative rates for the two races. The former high death rate for negroes from measles may, therefore, be due to their greater liability to die of pneumonia.

Another factor consists in the changing economic and educational status of the two races. With measles, especially, lack of intelligent care is apt to cause disastrous results. Doubtless an improvement of the

economic and educational status of negroes would greatly reduce their death rate from measles. In many places at least the lot of the negro has been considerably improved, but it is still below that of the whites. That in spite of his inferior status the negro should have the lower rate for measles is all the more evidence of his relative immunity to this disease. Whether his former conditions of life were so bad as to more than compensate for his natural immunity is questionable.

Lack of adequate care is probably one of the reasons why the measles rate varies so much in different national groups in the United States. In 1900 the measles death-rate in children under one year was 379.2 per 100,000 for those of Italian parentage; 208.8 for those of Irish parentage; 119.1 for those of native parentage; and 219 for those of colored parentage. For reasons already discussed we should be careful in drawing conclusions from these data, but the facts indicate that status is a very important factor in the measles death rate. In the light of these facts we might be prone to explain the relatively high mortality from measles among the whites as due largely to the presence of large numbers of immigrant stocks of an inferior social and educational status. These stocks go largely into the Registration Area. They are notoriously prolific, and their infant mortality from most causes is high. Their presence naturally tends to swell the measles rate of the white population, but it should be borne in mind that a relatively high measles rate is found among the whites in most southern states where there is a small proportion of recent immigrants.

In order to gain a basis for further comparison I have calculated the ratio of deaths from measles to total deaths in the white and colored population of New York from 1910 to 1923 inclusive. The ratio of deaths from all causes in negroes and whites was 1 to 24.59, while the ratio of deaths from measles in negroes and whites was as 1 to 48.21, which indicates that the whites have almost twice as high a death rate from measles as would be expected from the general death rates of the two races. This can scarcely be attributed to unfavorable conditions in life since the negro population in New York is probably not as favorably situated as the majority of the whites.

Of special interest in this connection are the data on measles of the white and colored soldiers during the late war. I have compiled the data on measles given in the volume on Medical and Casuality Statistics (15) of the U. S. Army and have embodied them in the following table:

Admissions, Deaths, Days Lost and Discharges from Measles in the U. S. Army, April, 1917-December 31, 1919

	WHITE	COLORED
Admissions Number	90,112	4,870
Admissions Rate per 1,000	25.01	17.00
Deaths Number	2,228	116
Deaths Rate per 1,000	.62	.40
Days Lost, Number	1,723,795	106,551
Days Lost, Rate per 1,000	1.31	1.02
Discharges for Disability, Number	142	7

The data show that the proportion of deaths, death rates, and admission rate, days lost, and discharges for disability are all higher for white than for colored troops. The data for German measles show similar relations.

DIPHTHERIA

The relatively low death rate of negroes from diphtheria has often been commented upon. For each of the ten southern states reporting deaths of both negroes and whites from diphtheria the death rate, so far as reported, from 1914 to 1923, with the single exception of one year, 1921, in Maryland, has been higher for whites than for negroes; and in this exceptional case the negro excess was slight, (113.0 per 100,000 colored; 112.2 per 100,000 white). For the fifteen cities reporting negro deaths there has been somewhat more irregularity, but despite exceptions in a few scattering years the higher death-rates for the whites are very noticeable.

The census of 1880 gives the deaths from diphtheria in relation to 1,000 total deaths in several large areas in the United States as 39.80 for whites and 17.7 for the colored. For the same regions in 1890 the rates were 36.17 whites and 26.06 colored. In the returns for 1880 and 1890 deaths from croup were listed separately and it is significant that in both censuses the rates for whites were markedly higher than those for the colored population. Doubtless most of the deaths attributed to croup were due to diphtheria. For the Registration Area for 1890 the death rate from diphtheria among the whites was over twice as great as that of the colored (100.35 per hundred thousand as compared with 46.91). In the Registration Cities it was relatively still higher (118.15 whites; 47.21 colored). In the Registration Area of 1900 the death rates for white and colored respectively were 45.9 and 30.5. Among the native born whites we find still higher diphtheria

rates, 130.1 in 1890, and 59.1 in 1900, a circumstance due to the relatively small number of children among the foreign born.

In his valuable paper entitled *A Statistical Study of Diphtheria,* Dr. F. S. Crum ('16) states that "In thirty southern cities combined during the years 1909-1913, the average annual death-rate of the white population from diphtheria and croup was 13.7 per 100,000 of the population against an average rate of only 8.1 for the negro population." The statistics of the Metropolitan Life Insurance Company tell a similar story. In every year from 1911 to 1916 the rate for whites was over twice that for the colored among the wage earning policy holders. The higher rate for the whites was found in all the age groups up to adolescence, when the numbers became too small to give significant ratios.

While children and adults show a lower rate for diphtheria among negroes than among whites this relation is frequently reversed in infants under one year of age. From 1914 to 1923 inclusive there have been 8,047 deaths among white infants and 1,128 among the colored. The ratio of deaths (white to colored, 7.13) is rather less than it is for all causes, 7.47, thus showing a higher percentage of deaths among the colored population. The data on the diphtheria death rates of the white and colored population under one year show that for each of the years included in the infant mortality statistics for the Birth Registration Area since 1916 the rates for negro infants have exceeded those for whites. The same is shown in the census data of previous decades. After the first year the racial incidence undergoes a marked change, the rates for the whites showing a marked increase. Table 7 *bis* taken from the U. S. Mortality Statistics is particularly instructive on this point.

As the table shows, for every year from 1920 to 1927 the general death rate, both crude and adjusted, is markedly higher among the whites, and for every year the same is true for the several age groups. The excess of the white death rate shows itself even in the second year of life. The data on which the table is based include over 50,000 deaths so the chances that the relations disclosed are due to fortuitous variations are quite negligible. It seems, therefore, to be quite clearly established that the negro death-rate for diphtheria exceeds that of the whites in the first year and that after this time the rate for the whites is markedly in excess of that of the negroes. One might be tempted to suppose that the superior resistance of the negro children after the first year is due to

TABLE 7 *bis*

Death Rates from Diphtheria per 100,000 Population White and Colored in the U. S. Registration States of 1920, (1920-1927)

	1920		1921		1922		1923		1924		1925		1926		1927	
	W	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C
All Ages—Crude	16.0	8.6	18.5	10.2	15.2	10.2	12.7	8.0	9.8	6.9	8.0	6.8	7.6	6.2	7.8	6.8
All Ages—Adjusted	16.9	8.7	19.6	10.4	16.2	10.5	13.5	8.4	10.5	7.3	8.5	6.9	8.1	6.4	8.3	6.9
Under 1	50.1	72.6	49.3	87.4	51.6	69.6	41.0	85.3	33.7	59.5	29.5	49.5	23.9	42.3	20.3	41.3
1 to 4	93.9	40.9	104.0	46.4	90.0	55.0	74.0	41.1	58.1	37.1	45.4	36.2	45.8	35.7	45.8	37.9
Under 5	85.5	47.3	93.6	54.6	82.7	57.9	67.9	50.0	53.5	41.5	42.4	38.9	41.6	37.0	40.9	38.6
5 to 9	12.4	4.8	15.2	7.8	11.3	8.4	9.4	2.8	7.3	2.8	6.1	3.3	4.9	3.7	5.7	5.5
10 to 14	3.7	2.3	4.2	2.0	3.6	2.0	3.6	0.8	2.5	1.4	1.8	0.9	1.5	1.1	1.4	1.5
15 to 19	1.8	.8	2.0	1.5	1.5	1.0	2.0	1.7	1.3	1.4	1.2	1.0	0.9	0.6	1.1	0.8
20 to 24	1.3	.6	1.4	1.0	1.4	.5	1.1	.9	1.0	1.5	0.8	0.6	0.8	1.0	0.7	0.7
25 to 34																

the fact that a larger number of susceptibles have been killed off in infancy. I think, however, that the selective elimination of negro infants can account for only a small part of the low negro death rate from diphtheria in the later age groups. The reason for this opinion is that the death rate from diphtheria in infancy is too low to confer any considerable degree of protection upon the survivors. The number of children dying in the first year among the whites is considerably less than the number dying in any single year up to the fifth, but in the colored population deaths in the first year markedly exceed those of any subsequent year of the first quinquennium. Nevertheless, the rate for the colored population does not preponderate over that for the whites in the first year to a degree that would account for the excess mortality of the whites in the later age groups. In the Registration States of 1920 in 1922, for instance, I find that if we assume that negro infants died of diphtheria at the rate obtaining for white infants during that year the deaths from this cause would have been 78 instead of 106. The 28 excess deaths distributed among subsequent age groups would have very little influence in equalizing the death rates of the two races in the later age periods. It is quite evident, I think, that the extent to which natural selection may act in the first year is quite incapable of conferring upon the negro the degree of protection which is so strikingly shown by his low death rate in later life. It is true that the difference in the death rates in the two races affords an illustration of natural selection. But the differential death rates act on the basis of an inherent difference between the two races which antedates the action of selection instead of being caused by its operation during infancy.

It is a noteworthy fact that the percentage of positive Schick tests for diphtheria is much the same in negroes as in whites. Dr. L. T. Wright ('17) tested 210 persons all but three of whom were colored, and found that 86, or 40.95 per cent, gave a positive reaction while 124, or 59.05 per cent reacted negatively. Doull and Fales ('23) found a "slight but not significantly lower carrier rate among the colored children than among the white children" in the schools of Baltimore. Doull and Bull in studying a ward in Baltimore found that of 8,433 whites 4,741, or 56.2 per cent, gave a Schick positive test, while of the 561 colored 311, or 55.4 per cent, gave the same reaction. In addition Dr. Doull remarks "we also studied the Schick test and the efficacy of toxin-antitoxin in several institutions for negroes. The net results for all this work would seem to indicate that the negro and the white are not widely different with respect to antitoxin immunity to diphtheria."

It is probable that the low mortality of the negro from diphtheria depends mainly upon his ability to escape infection, since when the disease is once contracted it is at least as apt to prove fatal as it is in the whites. The ratio of deaths to cases in the District of Columbia (1908-1924) was 1 to 12.94 among the negroes and 1 to 16.77 among the whites. Likewise in New Orleans (1910-1919) the ratio of deaths to cases was 1 to 6.49 in negroes and 1 to 21 in the whites. As a rule the whites enjoy the advantage of greater promptness of diagnosis and treatment with antitoxin. How the ratio of deaths to cases would compare in the two races under similar environment and treatment we do not know. A close approach to this position is afforded by the experience of the American Expeditionary Forces, 1917 to 1919. While the admission rate for whites was much greater than for negroes, the case fatality of the negroes was the higher, but as only five fatal cases of diphtheria occurred in the negroes we cannot place much reliance on the ratio of deaths to cases.

WHOOPING COUGH

In striking contrast with the three preceding diseases, whooping cough shows a higher death rate among the colored than among the white population. In the Registration Area for births the rate in the first year of life is over twice that of the whites for every year from 1916 to 1924 inclusive. A similar high excess of negro deaths is shown in the four subsequent years of childhood, after which the death rate from this disease falls to a comparatively low level. In fact, over 95 per cent of the deaths occur in children under five years of age. The excess of negro mortality continues through several later years, although the number of deaths soon becomes so small as to make comparisons untrustworthy.

The same high rate for negroes is shown in the earlier records of vital statistics. Dr. Crum ('15) in his valuable paper entitled "A Statistical Study of Whooping Cough," states that "In Charleston, S. C., during the period 1822 to 1848, the average annual death-rate of the colored population was 650.5 per 100,000 against a death-rate of 305.8 for the white population." In five large southern cities cited by Crum the negro death-rate averaged over three times that of the whites, and the experience of the Metropolitan Life Insurance Company with its wage earning policy holders, 1911 to 1916 inclusive, showed a rate for the negroes nearly double that of the whites. In the latter data children under one year were not included.

Howard finds that in Baltimore whooping cough is "over five times as fatal for negroes as for whites," and he presents evidence to show that the virulence of the disease has undergone fluctuations during the course of several years. As to morbidity, Howard finds that it "was much greater among the whites than among the negroes." Crum showed that in Washington, 1908-1912, the attack rate was 23.6 per 10,000 among the whites, and 22.5 among the negroes. With infants under one year the attack rate was nearly twice as high among the negroes and was somewhat higher (177.8: 157.8) in years 1 to 4, but after the fifth year white children were attacked much more than the colored, (10 to 19 years, whites 7, colored 4.8). Both Howard and Crum attribute the low morbidity rate of the negro largely to incompleteness of reporting.

It is probable that the high mortality of colored children from whooping cough is a result of the associated pulmonary affections to which the negroes are so susceptible. Out of 1,000 deaths from this disease in the mortality experience of the Prudential Life Insurance Company, 62.7 per cent presented pulmonary complications, mainly pneumonia (Crum).

MALARIA

The natural immunity of the African negro to malaria has been discussed in scores of books and papers, but the matter has now been shown to be less simple than it formerly appeared. There seems to be quite adequate statistical proof of the conclusion that in several parts of Africa the death rate of whites from malaria has been several times that of the adult native population. The records of the U. S. Mortality Statistics, on the other hand, show that the negro death rate from malaria is several times that of the whites. In the Registration Area for 1921, for instance, it was 21.9 per 100,000 for the colored, and 1.9 for the white population. One obvious explanation of this circumstance is the fact that negroes are abundant in some of the regions of the south which are the most severely infested with malaria. If, however, we attempt to avoid the fallacy of geographical distribution by comparing the malaria rates for the two races in individual states and cities, we find an almost uniformly higher rate for the colored population. This is clearly indicated in the subjoined table which shows that in individual states of the south the rate for the colored exceeds that of the whites both in rural districts and in cities.

TABLE 8

Death Rate from Malaria per 100,000 Population White and Colored in Individual Southern States, 1921

	CITIES		RURAL DISTRICTS		TOTAL	
	W	C	W	C	W	C
Florida	3.5	25.4	23.7	36.7	18.6	33.9
Louisiana	4.4	17.6	28.2	30.8	20.5	28.0
Mississippi	17.5	66.6	37.2	63.0	35.4	63.2
North Carolina	2.8	14.1	4.6	12.5	4.4	12.7
South Carolina	4.7	46.1	10.4	45.5	9.6	45.5
Tennessee	9.2	41.9	11.0	25.3	10.7	30.3

The experience of the U. S. Army during the Great War yielded further data on racial susceptibility to malaria. Craig states that "The experience of our Army in this respect is similar to that of other armies and demonstrates that there is no such thing as a true racial immunity to malarial infections." One is scarcely justified, however, in alluding to the evidence as demonstrative. The white and colored troops were differently situated as to exposure to malaria both before and after their induction into the Army, so that the results are inconclusive either one way or the other. During the Civil War the number of deaths per 1,000 in the armies of the North was 17.4 for the whites and 30.1 for the colored.

The superior resistance of the native in the malarial districts of Africa has apparently been acquired largely through early infection. Koch found that most of the children in malarial districts harbored the plasmodia of this disease. The adult population that had not been killed off probably developed a partial immunity which protected them against the severe ravages of malaria which occur in unprotected races which come to live in the infested region. Even the American negroes who went to Liberia showed a marked susceptibility to malarial fevers. Whether in addition to the protection which the negro has acquired in his native habitat there is also a measure of real racial immunity, we are not, I think, in a position to decide.

The case mortality of the negro is greater than that of the white although not more so than it is for many infectious diseases and may be accounted for in the same way. Doctor F. L. Hoffman('18) has pointed out that in Mississippi, 1915-16, the morbidity rates for malaria were higher for the whites than for the colored. This held true for each of the twelve counties of the Yazoo Delta region of Mississippi in 1915-16 and for each of the groups of counties for which data are cited, the

differences in most cases being very marked. In the majority of these counties on the other hand, the death rate from malaria was higher among the blacks. During the Civil War the admission rates for malaria were markedly higher for the colored troops than for the whites, but geographical causes may be responsible for this circumstance.

ERYSIPELAS

All of the available evidence indicates that the negro enjoys a marked natural immunity to erysipelas. The disease shows no especial preference for particular geographical regions. It is ubiquitous in its distribution. In whatever period or place adequate data have been collected they consistently show the same low mortality of the negro race. Taking as a fair sample the deaths in the Registration Area for 1920 from 1920 to 1923 we have the following totals for a selected series of age groups:

TABLE 9

Deaths from Erysipelas in the White and Colored Population, Registration Area for 1920, (1920-1923)

	ALL AGES	UNDER 1	UNDER 5	10-14	14-19	25-29	45-49
White	9405	2972	3367	82	153	223	417
Colored	396	126	143	11	11	13	21
Ratio W. to C.	23.75	23.59	23.67	7.45	13.91	17.16	19.86
Ratio of deaths from all causes—W. to C.	7.78	6.52	6.51	5.75	3.87	4.25	5.91

The fatalities in the white population are much greater than among the colored for all age groups. Erysipelas is extraordinarily fatal in infancy, and since it tends to be spread in insanitary surroundings we should expect to find it much more prevalent among the colored race. Taking deaths under one year in the white and colored population from 1914 to 1923 inclusive we find a total of 7,498 whites and 248 colored, giving a ratio of 30.23 as compared with an expected ratio of 7.47 based on deaths from all causes. These data indicate that the proportion of deaths among the whites is relatively high in infancy and early childhood. Then it becomes reduced for a span of several years and becomes increased again in the more advanced age groups. There are few diseases in which a racial idiosyncrasy is more pronounced. One is naturally led to associate the negro's immunity to erysipelas with his similar immunity to scarlet fever. The negro's superior protection

against both of these diseases may depend upon a higher resistance to streptococci, which are held to be responsible for these maladies.

The relatively low negro rate for erysipelas is shown in the earliest available statistics. In the census for 1870 there were 3,037 deaths among whites and 116 among negroes attributed to this cause. These give a ratio of 26.18 whites to 1 negro as compared with an expected ratio based on deaths from all causes of 6.33 whites to 1 negro.

TETANUS

Tetanus, like erysipelas, is commonly a wound infection, the umbilicus being a frequent channel for the entrance of both infections in the early period of infancy. Both diseases might be expected to show a higher incidence among negroes, owing to the insanitary conditions which so frequently surround the negro infant. The high negro rate for tetanus may be plausibly explained as due entirely to these external factors. If so, this serves to point all the more strongly to the importance of the racial factor in the case of erysipelas.

SYPHILIS

Statistics on mortality from syphilis are admittedly far short of representing the real damage done by this disease. Deaths ascribed to syphilis are not numerous as compared with deaths from other causes. But if Osler was correct in his estimate,—and perhaps there was no one better qualified to judge,—syphilis would take the first rank among the fatal infections. All of the available evidence indicates that this disease is much more prevalent among the negroes than among the whites. According to some estimates over 50 per cent of the negro population is infected with it, but such opinions are not based on adequate data. One of the best indices of its relative prevalence in the two races is furnished by the examination of soldiers during the Great War. The admission rates were 12.63 per thousand for whites and 64.99 for the colored. For the U. S. Army in Europe the rates were less (5.90 white; 16.66 colored), but for the U. S. Army in the United States there was not only a greater prevalence of this disease, but a higher proportion among the colored troops (17.66 whites; 111.09 colored). Deaths attributed to syphilis were nine times as numerous among the colored as among the white soldiers, (.02 white; .18 colored per 100,000).

Valuable additional data are furnished by the statistics of the wage earners insured in the Metropolitan Life Insurance Company (1911

to 1920). Rates of mortality from syphilis were, white males, 16.4 per 100,000; white females, 7.1; colored males, 46.1; colored females, 25.7. For both sexes combined the death rate among the colored was about three times that of the whites.

Dr. J. W. Williams in reporting on 4,000 obstetrical patients in the Johns Hopkins Hospital found 2.48 per cent syphilitic among the white women and 16.29 per cent among the colored. In the stillbirths he found that 12.1 per cent died of syphilis among white infants and 45.2 per cent among the colored. There have been quite a number of studies of the relative prevalence of syphilis among the colored and white members of special groups such as the inmates of hospitals, asylums, prisons, etc., and their authors have made various estimates as to the extent to which syphilis is distributed in the two races in the general population. As these estimates are based on especially selected material we shall not consider them further.

Aside from the fact that syphilis is more frequently neglected and allowed to pursue an unchecked course among the negroes there is no conclusive evidence that it is on the whole more severe upon the latter race. Some medical writers remark upon the severity of syphilis among the negroes and attribute it to racial idiosyncrasy, while others express quite the reverse opinion. Keyes, for instance, in a standard treatise states that "Negroes, although utterly careless about treatment, are relatively immune to syphilis and rarely exhibit parasyphilitic lesions." There are, however, good indications that the two races react somewhat differently to this disease. Manifestations of neuro-syphilis appear to be more common among the whites. I have added together the deaths of the whites and the colored for tabes dorsalis and general paresis as well as syphilis for the years 1920 to 1924 in the Registration Area for 1920. There were reported for tabes 7,592 deaths among the whites and 496 among the negroes giving a ratio of 15.31 whites to 1 negro. For general paresis there were reported 25,586 deaths among the whites and 3,174 among the negroes, giving a ratio of 8.06 whites to 1 negro. There were 23,206 deaths attributed to syphilis among the whites and 11,996 among the negroes giving a ratio of 1.93 whites to 1 negro. The ratio of white to negro deaths from tabes was about three times as high as it was for all causes, and for general paresis somewhat higher than it was for all causes, while it was less than a third as high as for all causes in the case of deaths attributed to syphilis. The experience of the Metropolitan Life Insurance Company 1911 to 1916 gives somewhat different results. The ratio of white to negro deaths for tabes is

greater than it is for all causes, namely 7.57 white to 1 colored instead of 4.51 white to 1 colored, but for general paresis it was 3.66 white to 1 colored or somewhat greater relatively among the negroes. The latter difference may be due to differences in the relative proportion of cases assigned to general paresis and to syphilis in the two sets of returns. It is probably also due in part to the difference in age composition between the insured group and the general population. Dr. Zimmerman ('21) who has made a comparative study of syphilis in negroes and whites states that the former manifest more severe osteo-arthritic and cardio-vascular symptoms, more polyadenitis and iritis, but less tabes and paresis than the whites. Thompson and Kingery ('19) find in agreement with Hazen that while syphilis may express itself in characteristic ways in negroes and whites there is "no difference in the course of the disease in the two races," or in their response to treatment. Characteristic skin manifestations, however, have been described by a number of writers.

Syphilis is undoubtedly the chief factor in the relatively high rate for stillbirths and abortions among the negroes, and is an important factor in early infant mortality. According to the mortality statistics of the Registration Area, 1914 to 1923, infant deaths from syphilis have been over three times as frequent among negroes as among whites. Owing to its rôle in the causation of abortion, and early infant mortality, to say nothing of its contributing greatly to the death rate in later years, syphilis is a powerful force in checking the natural increase of the negro population. This fact is due to social rather than biological causes and it may be remedied in time. The success of the two races in grappling with the problem of syphilis will have much to do with the outcome of the biological struggle for supremacy.

TUBERCULOSIS

Much has been written on tuberculosis in the negro. The course of tuberculosis among negroes before and after the Civil War has been treated at some length in the papers of Hoffman ('96) and Corson, to which the reader may be referred for fuller data on this phase of the subject. The native African tribes seem to have been relatively free from tuberculosis, but like many other peoples who have not been in contact with this disease they are particularly susceptible to its ravages when once it gains a foothold. This is certainly true of the natives of several parts of Africa today. And it proved to be true of the African troops recruited during the Great War.

During the period of slavery the negro death rate from tuberculosis

was probably not high. There are very few statistical data on the subject and these relate mainly to cities where tuberculosis was doubtless much more common than in rural communities. In Charleston from 1822 to 1848 the negro death rate was somewhat below that of the whites, although the white rate was very high. In Baltimore we have the death rates for negroes and whites for only one year before the Civil War, namely 1850, when the mortality rates for pulmonary tuberculosis were calculated by Frick as 317 for the whites and 468 for the negroes.

As opposed to these data on urban death rates we have a somewhat better index to the prevalence of tuberculosis furnished by the recruiting statistics collected during the Civil War, 1861-1865. These data were based on the examination of 315,620 whites and 25,828 colored recruits. Those rejected for tuberculosis amounted to 11.4 per thousand examined among the whites, and only 4.2 per thousand among the colored. Scrofula, however, (which is due to tuberculosis) was a little more prevalent among the colored recruits (2.8 per thousand white, 3.8 per thousand colored). Further evidence of the relative rarity of tuberculosis in negroes before the Civil War is furnished by the testimony of several physicians having extensive experience among the colored population. Dr. Buckner, who examined over 1,600 recruits remarked that "Tuberculosis is very rare among them; and contrary to the generally received opinion in the slave states, they are now as far as my experience goes, no more subject to scrofulosis than other people." Corson states that "I have been assured by physicians who practiced among them before the war, and when their physical condition was so much better than it now is, that consumption was almost unknown. The finding of any tubercular lesions in the lungs at an autopsy was always a surprise."

While the colored recruits during the war showed a relatively low rate for tuberculosis, the disease rapidly spread among them and soon caused a death rate far in excess of that of the white soldiers. Among the white soldiers the average annual case rate for consumption (1861-1865) was 6.06, and the death-rate 2.18 per thousand. Among the colored troops the corresponding rates were (1862-1865) 7.26 and 6.31. Death-rates per thousand for respiratory diseases among white and colored troops were 7.40 and 32.35 respectively. These facts seem to indicate that the negro was unusually susceptible to pulmonary diseases when once brought into intimate contact with them. Doubtless the living conditions of the negro soldiers were not so favorable as those of the

whites, as is indicated by their higher death-rates from most other diseases, the mean annual death-rate for the whites being 53.48 and that of the colored 143.40. Dr. Hunt in his valuable report on "The Negro as a Soldier" expresses the opinion that "While it must be admitted that temporary causes had much to do with the frequency of lung diseases among the negroes, it will still be found that they are vastly more liable to this source of mortality than the whites . . . . It was found that when fairly enlisted, clothed and fed, and subjected to the same methods of life as the white soldier he still exhibited a far greater ratio of deaths from pulmonary disease." Corson states that, "to the physician treating the disease among the colored, its great fatality is but too apparent. I can hardly recall a case where I have stayed it and they died without the slightest response to treatment and in a very short time." The proneness of the negro to succumb quickly to tuberculosis has been frequently commented on. Unfortunately it has not been possible to obtain data on the tuberculosis death-rate of negroes and whites living under the same environmental conditions. Even in the army such differences cannot be entirely eliminated, since the factors of poor education and insanitary habits are always operative, to a greater or less extent. The serious ravages of tuberculosis among the negroes following the Civil War are doubtless to be attributed to a large extent to the wretched housing and insanitary environment under which so many of the negroes were compelled to live. Crowded into small cabins, frequently with nothing but dirt floors, insufficiently clad and fed, often infected with malaria and syphilis, the negroes were exposed to almost ideal conditions for the spread of pulmonary diseases. Their death-rate from tuberculosis for the first three or four decades after emancipation came to be about three times as great as that of the whites. Data are not available for tracing the course of their tuberculosis death-rate during this period in any large part of the United States, so we must rely upon the statistics of a few cities which kept fairly adequate records.

Perhaps the most valuable records of the course of tuberculosis in the two races are those furnished by Howard ('24) from the vital statistics of Baltimore. In this city separate tabulations of deaths in the two races have been kept from 1875 to the present time. These official records have been modified by Howard by adding to the deaths recorded for Baltimore those inhabitants who died in Sanatoria outside the city. As thus corrected the deaths of the white and colored population of Baltimore are given in the following table. A more extended table

TABLE 10

Death Rates per 100,000 White and Colored Population of Baltimore, Md., 1876-1920

PULMONARY TUBERCULOSIS

Years	White	Colored	Years	White	Colored
1876-80	299	633	1901-05	189	488
1881-85	279	667	1906-10	179	498
1886-90	237	552	1911-15	148	444
1891-95	199	485		129	
1896-00	174	440	1916-20	150[1]	406

ALL FORMS OF TUBERCULOSIS

Years	White	Colored	Years	White	Colored
1901-05	215	559	1911-15	173	529
1906-10	203	562		150	
			1916-20	172[1]	487

[1] Inclusive of five years average of pulmonary deaths in sanatoria.

giving death-rates of the white and colored of both sexes year by year is given in Howard's report (page 381) as well as other tables for particular age groups of whites and colored, male and female.

We do not have reliable data on death-rates for large areas in the United States previous to the census year of 1890. The data after this period give an indication of the changes in mortality from tuberculosis in the white and colored population of the Registration Area. They are presented in the following tables.

Since 1911 the United States Mortality statistics have given the annual death-rates of the white and colored population of a number of states and cities. These data, which are given in tables 11 and 12, afforded a fairly adequate picture of the trend of mortality from tuberculosis during recent years.

All the preceding data clearly show a decline in the death-rate from tuberculosis for both whites and blacks, but our knowledge of the early part of this decline is quite indefinite. The death-rates for whites from this disease began to decline before the Civil War. The tuberculosis death-rate of the colored population increased after the war and then declined, but when the highest death-rate occurred is uncertain. The Baltimore statistics show the death-rate among negroes increased from 1875 to 1883 when it reached its highest point. For the whites the highest rate after the Civil War (318) occurred in 1876, after which there was an irregular but slow decline. In general, the death curves of the two races take the same course but the decline in the whites is more rapid until about 1900 when there is a rise for a few years fol-

lowed by a decline after 1906; after 1909 the mortality began to decline also in the blacks. Up to the year of the great influenza epidemic the tuberculosis rate of the negro had made little improvement in 25 years. During the decade between 1900 and 1910 its general course was rather upward than downward.

The trend of the tuberculosis death-rate of the two races in the District of Columbia is similar to that in Baltimore. The highest rate (7.05) was for the period 1885-1889, after which there was a fall followed by a period of about 15 years with relatively little change; this was succeeded by a relatively rapid decline which has characterized the tuberculosis death-rate in most localities during the past few years. The general course of the tuberculosis death-rate given in tables 11 and 12 shows that the decline since 1900 has been very uneven. There are consistently relatively low rates since 1918 or 1919. This may be due in part to the influence of the great epidemic of influenza in carrying off many ailing persons who would otherwise have died of tuberculosis somewhat later. In part it is probably due to the same causes,—whatever they are,—which were responsible for the previous decline.

Significant differences in the age distribution from deaths from tuberculosis are shown by the white and colored races. Even in the first year of life the rate is higher among the colored as is shown in table 13 and our data compiled in table 25. The relatively lower negro rates from tuberculous meningitis and abdominal tuberculosis should not be taken too seriously. The percentage of error in the diagnosis of tuberculous meningitis as shown by the investigation of the Census Bureau in 1911 was over 20 per cent; and it is probably higher for negroes, especially in the first year of life. The data on abdominal tuberculosis are based on relatively few cases (147) of negro deaths and comprise many cases which would probably be classed differently by different physicians.

The ratio of negro to white deaths rises until the period of adolescence when it reaches its maximum, but it continues to be relatively high even in old age. Among men of the ages of military service the tuberculosis rate of the negro is relatively high. The recruiting statistics gathered during the late war showed, in striking contrast to those of the Civil War, that the rate of admissions to sick report for tuberculosis of the lungs was over two and one-half times as high among the negroes as among the whites. "This," say Love and Davenport ('19), "is a little greater difference than the average of the past ten years when the

TABLE 11

Death Rates from Tuberculosis (all forms) per 100,000 Population White and Colored in Several States, 1911-1926

YEARS		VA.	TENN.	MD.	KY.	N. C.	S. C.	FLA.	LA.	MISS.
1911	W			151.3	196.7	182.4				
	C			438.0	483.1	389.3				
1912	W			149.2	178.9	166.4				
	C			385.7	439.8	363.2				
1913	W	117.2		146.1	172.7	168.0				
	C	276.5		408.0	424.7	331.7				
1914	W	122.4		154.1	174.6	181.7				
	C	307.6		410.5	489.8	366.1				
1915	W	116.8		142.6	168.2	152.3				
	C	328.0		402.1	485.7	379.0				
1916	W	118.4		148.6	163.7	101.5	67.0			
	C	301.7		420.8	467.4	249.4	217.2			
1917	W	109.2	155.6	150.8	166.2	94.2	70.0			
	C	307.6	374.5	413.6	486.1	236.4	213.0			
1918	W	126.1	151.5	163.1	169.3	94.7	67.9		109.0	
	C	315.9	432.5	423.4	466.0	238.8	215.4		302.9	
1919	W	97.5	126.6	129.4	143.1	86.0	68.0	74.9	80.8	57.3
	C	272.0	344.9	344.2	367.8	205.9	199.0	161.6	241.7	207.1
1920	W	94.8	129.3	110.4	130.3	82.8	65.5	67.1	80.9	47.8
	C	256.2	312.6	326.6	363.8	194.2	172.0	176.8	236.2	201.2
1921	W	86.1	106.6	102.1	109.9	69.3	52.4	62.4	69.4	49.5
	C	246.0	282.0	301.8	331.1	187.4	168.0	162.5	207.2	167.2
1922	W	86.9	113.7	101.1	115.6	71.0	49.7	64.8	69.4	48.4
	C	234.8	296.8	275.7	299.0	176.2	168.0	174.5	201.7	161.3
1923	W	81.2	120.7	91.7	118.8	72.0	52.7	69.7	66.7	45.3
	C	217.7	286.4	292.8	277.9	163.7	157.1	174.0	192.5	150.2
1924	W	75.9	111.2	91.0	105.2	69.2	48.5	55.8	66.4	49.4
	C	201.5	307.5	275.8	264.2	179.2	154.0	149.0	190.6	158.4
1925	W	73.2	104.9	87.0	105.2	68.3	42.5	50.6	64.8	49.3
	C	198.7	285.0	293.7	263.7	173.3	146.0	141.9	180.0	160.9
1926	W	71.5	111.0	86.3	106.2	64.1	42.5	57.9	59.7	50.7
	C	191.9	320.7	259.6	299.7	179.4	142.1	162.6	185.5	163.1

TABLE 12

Death Rate from Tuberculosis (all forms) per 100,000 Population, White and Colored in Selected Cities

1906-10 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926

TABLE 15

Death Rate from Tuberculosis (all forms) per 100,000 Population, White and Colored in Selected Cities

CITIES		1906-10	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926
Atlanta	W	145.8	125.8	96.4	101.5	95.4	86.9	95.7	89.8	98.9	77.9	84.6	65.0	65.9	69.5			53.7
	C	305.3	327.1	242.5	250.3	218.2	236.5	266.1	252.7	205.8	205.5	161.0	239.0	215.3	222.3			228.0
Baltimore	W	206.4	183.6	188.4	174.4	170.9	158.2	159.2	165.7	180.3	128.7	113.3	96.3	96.4	87.8	89.8	82.6	80.3
	C	584.5	598.8	557.7	570.0	500.3	511.8	521.7	542.2	536.6	407.8	357.1	388.1	332.0	355.5	291.9	339.9	280.7
Birmingham	W		113.8	122.0	100.2	116.3	98.0	91.2	69.8	87.0	65.0	66.3	52.2	51.7	47.1	59.0	51.2	50.0
	C		413.2	341.0	432.8	487.5	427.5	432.8	467.4	401.2	332.8	307.6	288.6	274.6	266.5	234.7	276.5	232.2
Dallas	W							91.5	94.5	115.5	76.8	70.8	54.8	63.1	49.8	75.9	50.7	63.6
	C							384.5	364.4	335.4	200.2	342.9	270.4	255.3	160.4	233.0	199.2	232.2
Houston	W								88.8	144.8	78	81.1	93.3	69.8	88.2	77.1		
	C								294.5	288.4	237.5	201.0	180.5	247.9	218.5	225.8		
Indianapolis	W					175.2	163.9	152.3	152.9	141.3	120.1	101.9	101.1	89.9	84.4	75.1	74.9	73.1
	C					539.5	494.1	444.3	399.9	447.7	316.4	358.3	310.0	296.4	299.1	255.0	262.4	259.8
Kansas City, Kansas	W					120.9	117.7	107.4	116.4	113.5	87.3	88.1	76.7	94.7	84.2	85.7	83.7	87.1
	C					361.5	354.4	332.1	273.4	285.0	387.4	230.8	367.3	217.2	333.2	350.6	422.7	234.7
Louisville	W	182.9	198.1	164.0	147.1	174.3	141.0	136.7	131.9	177.9	141.0	115.8	98.9	103.2	105.5	84.5	89.5	82.8
	C	429.9	408.1	411.9	357.6	412.9	421.4	427.5	438.4	449.4	363.4	267.0	292.7	257.4	196.6	192.4	214.7	246.9
Memphis	W	157.7	146.7	161.5	158.1	124.1	142.0		145.1	152.0	110.3	108.8	80.8	77.4	92.7	75.5	67.2	69.5
	C	367.8	382.9	292.2	428.7	602.6	559.1		515.8	567.1	454.8	369.8	317.8	322.8	326.2	379.1	322.3	298.0
Nashville	W	188.7	165.0	161.8	145.7	139.2	138.9		145.8	146.6	131.3	131.0	95.6	98.9	99.0	102.6	81.4	111.3
	C	455.0	396.0	401.9	358.3	448.4	466.2		343.2	486.8	353.0	390.5	309.0	325.0	288.2	345.1	288.0	302.6
New Orleans	W	206.3	173.2	182.1	159.3	196.4	177.7	174.1	208.3	227.3	166.2	157.1	136.2	131.1	124.0	120.9	122.7	110.7
	C	528.1	503.8	498.1	516.3	570.1	659.0	626.0	638.9	563.8	408.2	354.3	341.4	331.8	315.6	304.7	358.5	330.8
Norfolk	W					122.0	93.9	88.5	74.4	116.9	64.8	93.9	51.5	62.9	52.2	48.7	37.1	27.9
	C					325.5	352.4	337.7	313.8	327.0	276.8	301.5	194.8	229.4	239.9	222.6	181.7	188.9
Richmond	W	189.1	162.3	178.9	130.3	127.0	129.6	134.2	122.1	145.8	121.3	114.5	91.5	76.0	78.4	72.2	58.7	53.1
	C	380.4	403.3	361.3	334.1	377.8	355.7	382.4	311.8	318.1	277.9	249.1	264.9	267.5	259.3	207.4	204.7	240.0
Washington	W	163.2	158.2	140.3	151.0	112.2	115.5	108.8	102.9	116.7	105.3	85.0	75.2	79.6	79.3	65.9	54.8	62.2
	C	525.6	461.8	509.8	447.8	420.5	439.1	411.3	356.4	369.5	287.5	277.1	278.2	294.4	260.3	287.2	286.6	279.5
Ft. Worth	W													47.7	44.6	52.5	57.4	31.4
	C													154.1	147.7	107.6	205.3	196.9

TABLE 13

Death Rates According to Age per 100,000 Population of White and Colored from Tuberculosis in the Registration States of 1920 from 1920 to 1923

	1920		1921		1922		1923	
	W	C	W	C	W	C	W	C
All ages—Adjusted	96.2	263.0	82.3	242.5	81.1	237.4	79.4	231.5
All ages—Crude	99.5	263.5	85.3	243.2	84.1	238.2	82.4	232.2
Under 1 yr.	103.4	195.1	92.2	180.7	85.5	172.8	77.0	174.6
1-4 yrs.	40.6	92.1	32.3	86.4	31.4	89.7	31.2	99.4
Under 5	52.7	112.7	43.8	105.3	41.7	106.3	39.8	114.4
5-9	14.9	57.1	12.7	44.0	10.9	38.3	11.3	40.6
10-14	19.0	93.6	16.2	82.4	14.3	71.7	13.6	71.3
15-19	78.2	310.0	67.4	290.2	67.9	270.7	67.5	279.6
20-24	138.8	493.2	120.7	453.8	118.3	443.7	118.2	417.4
25-34	145.0	409.9	119.9	395.0	120.1	388.1	114.8	382.5
35-44	133.8	314.8	112.9	281.9	109.8	288.4	108.1	272.6
45-54	125.0	269.9	108.9	248.5	107.1	235.1	104.6	227.4
55-64	134.3	264.4	121.7	244.4	118.9	250.8	116.3	248.0
65-74	155.9	282.3	141.2	228.2	149.4	258.3	149.8	209.1
75	145.4	233.3	127.7	234.5	129.0	215.7	133.0	194.7

colored have about two times the admission rate of white troops. In tuberculosis of other organs the rate for the colored troops is twice that for the whites." In speaking of tuberculosis among adolescent negroes insured by the Metropolitan Life Insurance Company Dr. Dublin remarks, "The disease is a veritable scourge among young negroes. At the ages between ten and fourteen years the tuberculosis death-rate among colored boys is eleven times as high as it is among white boys of the same ages. Colored girls of the same age period show a tuberculosis rate eight times greater than that of the white girls. Tuberculosis is preëminently a disease of young people but it is especially among colored people. In fact, the great excess of tuberculosis mortality among negroes is almost entirely limited to the early years of life. After age 35, there is not much difference in the effect of the disease in the two races. The disease runs a more rapid course among negroes, perhaps, because the power of resistance to the disease is much lower among these people than among the whites. More than five years could be added to the life span of colored people if tuberculosis were brought under control."

In attempting to understand the reasons for the distinctive characteristics of the negro death-rate from tuberculosis we must consider a number of factors. The greater prevalence of malaria among negroes is a predisposing cause of only minor importance. Of greater influence is the effect of syphilis, which is much more prevalent among negroes than among whites. The extent to which tuberculosis is aggravated by this disease cannot be measured but it is undoubtedly very considerable. Then, there is the effect of ignorance, bad housing, overcrowding, improvidence, and the various other environmental factors about which so much has been written. Properly to evaluate the influence of these factors as compared with the effect of a hereditary diathesis is a difficult problem which still shows little prospect of speedy solution. The extensive controversial literature on the subject has at least brought out the fact that the field is full of pitfalls and that it is very dangerous to take statistical evidence at its face value. It has been abundantly proven that tuberculosis runs in families, but this, as has often been urged, might be due to infection instead of heredity. The attempt of Pearson to meet this objection by showing that there is little correlation for tuberculosis between husband and wife where chances for infection are abundant, is met by the argument that tuberculosis is usually acquired in childhood, when in fact the great majority of individuals become more or less infected. Children commonly harbor the germs of tuberculosis until near or after the period of adolescence when the disease may develop in acute form. But on the other hand, it may be said, that if most people become infected early in life, whether they come of tuberculous parents or not, and if children of tuberculous parents most frequently show the disease, it indicates that the deciding factor is to be sought in the constitution of the individual. While the proponent of the tuberculous diathesis may plausibly justify his interpretation of the fact by employing this argument, we should not lose sight of the possible influence of repeated and mass infections which are now known to be of great importance in many infectious diseases. In several families studied by Pearl there was a larger number of tuberculous children in tuberculous families where there was close contact with the diseased individual than in tubercular families in which the contact was less close. Slater in a study of 1,654 school children in a rural community in Minnesota finds that among children who had been exposed to tuberculosis 81 per cent gave a positive tuberculin reaction; of the children who were unexposed only 5.3 per cent gave a positive reaction, while for cases of doubtful exposure the percentage of positive reactions was

8.6. All that we are justified in asserting at the present time is, I believe, that the direct evidence in favor of the heredity of a tubercular diathesis is plausible, but not rigidly demonstrated. The presumption in favor of such an inheritance is considerably strengthened by the fact that in animals it is possible to show, as Wright and Lewis have done in guinea pigs, that different strains have varying degrees of resistance to tubercular infection. A geneticist familiar with inherited differences in reaction to diseases manifested by races of animals is naturally disposed to look for similar phenomena in human beings. Doubtless much can be learned from the little cultivated field of experimental epidemiology in animals.

The study of epidemics among different races of man appears to yield evidence of the rôle of hereditary racial factors. But there are pitfalls. We read of a relatively mild disease such as measles proving a fatal scourge among the Polynesians and we conclude that these natives do not enjoy the same immunity to this disease as the whites. But so competent an epidemiologist as Dr. V. C. Vaughan is not convinced that we would fare any better if we lived like the native Polynesians and were suddenly struck by a strange epidemic which left few well people to look after the sick. It is usually difficult to separate social factors from others with which they are associated and in no case more so than in the colored population living in our midst. Many writers speak naively of the two races in a given area being exposed to the same environment regardless of the fact that food, clothing, housing, and exposure to various epidemics may differ as greatly as the most wholesome residence on Fifth Avenue differs from the most crowded tenement in Harlem. The statistician may some time measure and evaluate the chief environmental factors which contribute to the differential death-rate. Frequently this task is regarded as much easier than it really is. In studying the influence of poverty on the death-rate from tuberculosis we might compare the relation of this death-rate with wages. But finding, as in fact we do, that the death-rate from tuberculosis goes up as income goes down does not prove that the small income is responsible for the increase of tuberculosis. Both may be due to ignorance and incompetence and we should bear in mind also that persons, because they are tuberculous are unable to earn as much wages as those who are healthy.

Where improvement in conditions in life is promptly accompanied by a reduced death-rate from a given malady the environmentalist has a very plausible case. I think that few would deny that improved hygiene

and sanitation have been factors in the reduction of the death-rate from tuberculosis, although Pearson and his followers may be right in their contention that the race is becoming, for some reason, less susceptible to this disease. I cannot, however, see much force in Pearson's arguments based on the trend of the tuberculosis death-rate. Nor is there anything in the course of the tuberculosis death rate in the negro which affords more than presumptive evidence toward the solution of our problem. The negroes were unusually susceptible to tuberculosis when the disease was first well introduced among them as is indicated by their high death-rate and the rapid course of the disease when once contracted. Probably a large part of the decline in their death-rate is due to a gradually acquired immunity. Their improvement seems too rapid to be attributed to the ordinary operation of natural selection. Racial immunities to infectious diseases are probably built up chiefly by other methods such as the gradual immunization of individuals through minimal infections, aided in many cases by the transmission of antibodies through the placenta. By the latter method young children may derive a temporary immunity to some of the common infections early in life, and if in the meantime they become inoculated with very small doses of infectious material they may acquire a lasting protection. That children become gradually immunized to tuberculosis is indicated by the observations and experiments of Calmette on animals and human beings. To build up an immunity by the method described would probably not require more than a few generations and the colored race has certainly been exposed long enough to tuberculosis to profit by its contact. In fact, Dr. Bushnell ('20) thinks that the negroes were "tuberculinized" almost as much as the whites at the time of the Civil War, but this seems hardly probable in the light of the general course of the tuberculosis death-rate.

There have been few studies on the racial incidence of tuberculosis in which environmental factors have been excluded. Cunningham ('94) has found that negro convicts living under the same conditions and especially selected on the basis of sound physique showed much higher disease rates for pneumonia and tuberculosis than the whites. They were also inferior to the whites in chest development. Carter ('26a) found in comparing 5,000 white and 1,700 colored patients living in sanitoria under the same conditions that the whites improved much more than the negroes and that the mulattoes improved more than the blacks. He also observed that light colored mulattoes were more resistant to tuberculosis than the darker ones. These data on the mulattoes run counter

to a widely prevalent opinion among physicians as to the general weakness and high tuberculosis rate of the mulattoes as compared with pure whites or negroes. Grandy ('20) in studying 967 white and 822 colored children of Norfolk, Va., found that the colored children are heavier for their height and have a better posture than the white children and show in general good physical development, but they have a high rate for tuberculosis "due to a racial lack of resistance." Their living conditions, as Grandy points out, are "certainly no worse than those of some of our foreign born Jewish citizens who apparently show the greatest resistance to tuberculosis."

As Dublin and Baker have shown in their study of the mortality of foreign race stocks of Pennsylvania and New York, there are great differences in the death-rates from tuberculosis among peoples living in congested areas of our cities where the conditions are apparently the most favorable for the spread of tuberculous infection. The Jews, for instance, show relatively little tuberculosis in crowded urban districts which would cause a high death-rate among the negroes.

In the light of such facts it is difficult to escape the conviction that hereditary racial factors play a prominent part in the differential death-rate from this disease. This conviction does not rest upon demonstrative evidence, but it constitutes, I believe, the best judgment which can be made in the light of the various facts at our disposal. It is rendered probable *a priori* by what is known of the influence of racial factors in animals and plants, and more specifically by the differences in susceptibility of races of guinea pigs to tuberculous infection. We do not know to what extent differences in the process of immunization through minimal infections are responsible for the different ways in which the white and negro races react to tuberculosis. The problem is a peculiarly baffling one at present, but it can be solved if proper survey studies are carried on for a number of years on a sufficiently extensive scale with an ever watchful eye upon several matters which present alternative possibilities of interpretation.

(To be concluded)

A STUDY OF LIKE-SEXED TWINS

I. THE VITAL STATISTICS AND FAMILIAL DATA OF THE SAMPLE

BY PAUL THOMAS WILSON AND HAROLD ELLIS JONES

Institute of Child Welfare, University of California

A. INTRODUCTION

Genetic research with twins has been marked by an increasing use of quantitative methods. Thorndike's correlational studies, 1905 (20) presented an advance over the earlier anecdotal approach of Galton, 1883 (4). The recognition of identical twins, previously a matter of subjective estimate, was placed on a systematic basis by Siemens (16), who formulated (1925) a series of criteria and proposed the use of mathematical probability in connection with the duplication of heritable traits in dizygotic pairs. In the field of anthropometric measurement, Dahlberg's methods in the collection and treatment of data, 1926 (1) are worthy of note from the standpoint of attention to reliability. The method of the "individual pair difference coefficient," as applied by Merriman, 1924 (10) to identical and fraternal pairs; the experimental method of "co-twin control," as described by Gesell, 1922 (5) and the more elaborate formulae for statistical analysis developed by Holzinger, 1929 (6), have offered promise of substantial results in the analysis of hereditary variables influencing development; it is, however, manifest that such results are contingent upon the procuring of large samples, and their ultimate scope and significance would seem also to depend upon the thoroughness with which cumulative or "longitudinal" records are obtained.

In January, 1928, a survey was undertaken by the Institute of Child Welfare of the University of California,[1] with the purpose of establishing a representatively large sample of twins in the metropolitan district on the east shore of San Francisco Bay.

[1] Acknowledgments are due Prof. S. J. Holmes of the Zoology Dept., University of California, for the helpful suggestions and criticisms he gave during the earlier part of the investigation.

The present paper attempts to present a general account of the twin sample. This is designed as preliminary to a series of reports on the resemblance of twins in specific traits.

B. METHOD OF LOCATING TWINS

The school departments of Berkeley, Oakland, Richmond, and Alameda coöperated in the work of securing the names and addresses of twins.[2] In the first three cities, printed question sheets were distributed to every classroom teacher, who was asked to fill in the names, addresses, and sex of the twins in her room, including those pairs in which one member had died. At the same time she was requested to ask the children for identification data concerning any other twins of preschool or adult age.

In Alameda a somewhat different procedure was followed. This city keeps a complete record, by family, of all the children of school age within its limits. From this central file it was a simple matter to assemble the desired information concerning twins and their siblings.

The sample of preschool twins was also supplemented by searching the county birth records and the city directories, for evidence of plural births. A small number of additional pairs was secured by chance contacts or through letters to the Institute.

C. THE SCHOOL TWINS

Although we attempted to locate every twin within the given school population, it is probable that some pairs were missed. The school systems are large, and the methods of circulating and collecting the questionnaires necessarily complex, so that a rechecking of the results could not be made without an unreasonable expenditure of time. However, there are several possible checks on the completeness of our survey.

1. The number of twins in the Institute sample compared with the number in the general population

In the four cities investigated, the school enrollment, from kindergarten through high school, was 75,013. According to the California birth records for the years 1919 through 1924, 2.12 per cent of the children born were twins (1.06 per cent of the deliveries were twin deliveries; the similar figure for the entire registration area of the

[2] Particular acknowledgments are due to Dr. Virgil Dickson, Dr. R. E. Rutledge, Mr. W. T. Helms, and Mr. William G. Paden for their advice and active assistance in this connection.

United States being 1.16 per cent (26).[3] If the death rate of twins were the same as for the single born, we would expect these percentages to hold constant, and in our school population of approximately 75,000 we should therefore find about 1,600 individual twins. It is well known, however, that during infancy and the preschool period, the death rate for twins is considerably higher than for the single born. Westergaarde (23), using records of English insurance companies, gives data on the death rates of twins that suggest the amount of this difference. He found that at five years of age two-thirds of the female twins were living as compared with seven-eighths of the female single births; only one-half of the male twins were living as compared with five-sixths of the male single births. If his ratios are applied we would expect about 1,150 twins in our available school population. The actual number obtained (1,051) was fairly close to this figure.

TABLE 1

Number and Sex of all the School Twins[1] Identified

	MALE	FEMALE	MIXED	SEX[2] UNKNOWN	TOTAL
Individual twins with both members living	260	364	318	...	942
Twins with one member of pair deceased[3]	25	38	33[4]	13	109
Totals	285	402	351	13	1,051

[1] One set of triplets (girl-boy-boy) was also found.

[2] Sex of deceased member not given; in six cases the living member was male and in seven cases female.

[3] The data of this category are limited to Oakland, Berkeley, and Richmond. If this information had been obtainable for Alameda about 20 additional cases might have been found.

[4] Of the mixed pairs the surviving member was male in 11 cases and female in 22 cases.

2. *Sex Ratios*

Another check on the representativeness of our sample can be made by studying the sex ratio of the pairs. In Table 2 are tabulated the number and sex of the pairs in samples studied by other investigators. Merriman (10) and Lauterbach (9) believed they had a complete census of all pairs of twins in the given school populations. Wingfield's (24) sample was "selected at random from the public schools of Toronto and Hamilton." Dahlberg (1) and Verschuer (21) obtained their material from several sources, but do not discuss the possi-

[3] These include cases in which one member of the pair was a stillbirth.

bility of selection on the basis of sex or intra-pair similarity. Newman (12) studied 100 pairs of like sexed twins; the first 95 cases of which were "taken as they came" and had a sex ratio of approximately 50:50. The outstanding feature in all the samples (with the exception of Newman's small group) is the high percentage of female pairs.

TABLE 2

The Sex Distribution of Twins: A Comparative Table

	NUMBERS				PERCENTAGES		
	♂♂	♀♀	♂♀	Total	♂♂	♀♀	♂♀
Merriman	49	82	70	201	24	41	35
Lauterbach	71	78	63	212	33	37	30
Dahlberg	84	107	52	243	35	44	22
Wingfield	26	50	26	102	26	49	25
Verschuer	27	29	46	102	26	28	45
Total[1]	257	346	257	860	30	40	30
Institute Sample	130	182	159	471	28	39	33

[1] Five investigations only.

In the Oakland schools at the time this survey was made slightly more than one-half of the enrollment were males; the ratio being highest in the senior high school.[4] Among twins at birth the ratio of living males to females is about equal. In California, 1919 through 1924, the ratio was 1,005 males to 1,000 females. Knibbs (8) gives 1,037 to 1,000 in Germany, 1906-1913 (the ratio in single born was 1,055 males to 1,000 females). These figures included all deliveries in which one child at least was born alive. As stillbirths are more prevalent among males the proportion of live males among twins is even lower. Referring again to Westergaarde, we find that at the end of five years about 50 out of 100 male twins are alive, while there are 66 out of 100 females living. In other words, of 116 individual twins still living at the age of five 43 per cent will be male and 57 per cent female. When we assemble all cases located in our school sample (Table 1), we find that there are 461 males and 590 females: a ratio of 44 to 56 or almost exactly that found by Westergaarde in his 1891 English twin population.

In this connection, the data on pairs with one member deceased are

[4] The proportions (on September 2, 1927) were as follows: Kindergarten, 50.129% males; Elementary (including some 7th and 8th grade pupils), 50.328% males; Junior High, 50.410% males; Senior High, 52.439% males.

of some significance (Table 1). Of the 33 male-female pairs located, the male had survived in 11 cases as compared with 22 cases in which the female had survived; and where the sex of the deceased member was unreported, the survivor was male in six cases and female in seven.

The marked drop in the proportion of male school twins can apparently be accounted for only in terms of a differential death rate.

3. Institute Sample Compared with Merriman's

In 1923 Merriman reported a study of the twins in the elementary schools of Oakland. Describing his procedure he says, "Every possible effort was made to secure data upon every twin pair in a school population . . . . It is believed, therefore, that factors which could have produced a systematic tendency to overlook cases which were not in the same grade or which did not resemble, were pretty completely eliminated." These same schools were included in our survey made some six years afterward. In Table 3 are given the number and sex of the pairs of his sample and the same for the pairs we found in the Oakland Elementary schools (including Junior High).

TABLE 3

Oakland Elementary School Twins in Twin Samples

	NUMBER OF PAIRS FOUND				RATIO (IN PER CENT)		
SOURCE	♂♂	♀♀	♂♀	Total	♂♂	♀♀	♂♀
Merriman	49	82	70	201	24.4	40.8	34.8
Institute Survey[1]	85	93	76	254	33.5	36.6	29.9

[1] One set of triplets (girl-boy-boy) not included.

The difference between the total number of pairs may be explained by the increase in school enrollment during the intervening years. Among the boy-boy pairs, Merriman's percentage is slightly lower than is usually found.

4. Pre-school and Adult Twins

In Table 4 is given a tabulation of the numbers and sex of twin pairs of adult and of preschool age. Since these cases were obtained as an incidental part of the school survey through the reports of acquaintances rather than through a direct canvass, no claims can be made concerning their representativeness. The low proportion of unlike-sexed pairs in both groups is probably an example of the tendency for twins of this type to be overlooked. In addition to the 259 pairs

listed in Table 4, 103 pairs were reported in which the sex of only one member was given. It is possible that if these were more fully traced, the proportion of mixed pairs would rise.

TABLE 4

Number and Sex of Pre-school and Adult Twin Pairs

	NUMBERS				PERCENTAGES		
	♂♂	♀♀	♂♀	Total	♂♂	♀♀	♂♀
Pre-school Twins	41	48	26	115	35	42	23
Adult Twins	49	62	33	144	34	43	23

C. INTERVIEW PROCEDURE

In order to make the sample as homogeneous as possible by minimizing sex, language, and race differences, it was planned to limit the first survey sample to like-sexed twins of school and preschool age, and to twins both of whose parents were of the white race and born in the United States or in Northern Europe.

Before any extensive study could be made of the twins, the consent of the parents had to be obtained. Therefore the next step after the identification of the sample was an interview with a parent or guardian (usually the mother) in each family. Another function of the interview was the accumulation of certain familial and developmental data.

Prior to an interview the following steps were taken:

1. The school identification data were used for the purpose of sorting the families into districts which could be reached conveniently during a single day of field work.

2. An introductory letter was sent to the mother:

> .....(Name of mother)
>
> As a part of our research on factors influencing child growth and development, the Institute of Child Welfare of the University of California is planning a special study of twins. Parents and other relatives of twins have been deeply interested in this inquiry, and have given us information of great value concerning the problems on which we are working.
>
> A member of the Institute staff will call on you in the near future in order to explain the purposes of our study and to solicit your coöperation in this work.
>
> Very truly yours,
>
> .....

3. If the home had a telephone the mother was called within a day

or two after she received this letter, and an appointment was made. The telephone call was made usually between five and seven in the evening. Six appointments represented about the maximum for one day's work, the time for each interview varying between thirty and ninety minutes. The average time was somewhat reduced as the worker gained skill in the interviewing.

The interviewers (Paul T. Wilson, Maye P. Mudge, and Virginia Currie) were supplied with the following typewritten instruction blank:

In entering the home the worker attempts to maintain an informal manner; there is no display of a brief case nor of papers which would suggest a salesman or a census taker. The preliminary discussion of the worker's project is kept as informal as possible and is, of course, adapted to the mental level and the interests of the mother who is interviewed. The following items are usually covered:

> "The Institute is making a study of the development of children, their rate of growth, their illnesses; factors which aid or hamper their development. In this study twins are known to be of the greatest scientific interest. Some twins are very much alike, others very different, both in appearance and disposition, although the two children may have always lived together and received practically the same care. One of the things we wish to study is the origin of these physical and mental differences in twins who have always been given about the same environment. The first step in such a study is to talk with the mothers because they know more about the children than anyone else."

At an appropriate time during the introductory conversation, an interview record form (consisting of a four page booklet) is brought out and its purpose explained as a convenient way of keeping track of the information secured.

The mother frequently will show a tendency to speak of the twins as a unit, "*They* have always been very healthy children!" Early in the interview it is explained that we are particularly interested in the *comparison* of the characteristics of the two children. Often it is best to ask specifically if there is any difference between the two in a given trait, but the interviewer must remember that under these conditions the mother may invent or exaggerate differences. Care must be taken to obtain the mother's true opinions, free from dramatizing or conversational forcing.

It should be pointed out that the interview procedure was merely preliminary to a later direct study of the twins. Since most of the interview data depended upon the mother's memory, it was not expected that it could be free from inaccuracies. Where the information desired is quite objective, such as "age of mother at birth of twins," the probability of error is of little significance. However, if the questions concern "efficiency in school work" or "tendency to headaches," the possibility of error is obviously greatly increased. One of the leading difficulties is to obtain data which are comparable, without disturbance

from variables associated with the mother's degree of coöperation, the time of the visit, or the mood of the interviewer. Notwithstanding these sources of error, the interview method offers possibilities of securing certain very valuable information which can be obtained in no other way. All information concerning the family history and the past development of the twins is of this kind. In addition, because of the intimate contact between the mother and children, much data of a suggestive and supplementary nature can be secured concerning characteristics which may later be measured objectively.

In the face of the difficulties of securing reliable data, every effort was made to standardize the interview as much as possible and still meet the needs of the moment. The questions were made definite with the idea of securing categorical answers. A detailed instruction blank was provided, indicating the procedure for each of a total of approximately 100 items which were to be covered in the interview. It was so arranged that the information could be recorded with a minimum of writing by using numbers and symbols to indicate degree of similarity or difference in a trait. The three workers, by conference and use of the same instruction sheet, made every effort to maintain equivalent methods.

The highly coöperative attitude of the parents, and their readiness to talk about their children, proved to be a great aid in the satisfactory completion of the survey. The writers take this opportunity of acknowledging the interest and assistance of the 212 mothers who coöperated in the study.

The validity of all information pertaining to a comparison of identical and fraternal twins is based upon the assumption that these are two distinct classes and that they can be distinguished by the use of standard procedures. The leading workers in this problem agree that a skilful, experienced investigator can readily distinguish the two types in a great majority of the cases. Siemens (17) believes that "certain diagnosis is possible in virtually every case of twinning." Newman (12), in one of the latest papers on the problem, says "at the beginning it may be said that in over 90 per cent of our cases there was at no time any doubt as to these classifications." In a study of 102 same-sexed twins "there was justifiable doubt in about only six cases."

His criteria, which are very similar to those used by Siemens and Dahlberg, are as follows:

1. They must be strikingly similar in general appearance including various intangible resemblances.

2. They must be essentially identical in hair color, texture and form.
3. They must have the same shade of eye color and form of iris.
4. They must have the same skin color and texture (complexion) except when one is more tanned than the other.
5. They must have no marked differences in features; shape of ears; shape, size and arrangement of teeth.
6. They must have hands of the same type and nearly equal in size.
7. The general microscopic character of the papillary ridges in fingers and palms must be essentially the same.
8. There must be stronger cross resemblance than internal resemblance in one or more of the details of finger and palm patterns.
9. The presence of reversed asymmetry in handedness or hair whorl in one twin is confirmatory evidence of monozygosity, but its occasional presence in unlike twins is not to be taken as an indication of monozygosity.

The first five criteria are perhaps the only ones that can be satisfactorily used when the data are obtained in an interview. It seemed desirable to make the classification of identical and fraternal at the beginning of the interview, before the worker could be prejudiced by subsequent information concerning personality traits, disease records, etc. In this connection, however, it is possible to set up an additional criterion not mentioned by previous investigators; namely, developmental correspondence. An illustration of the use of this criterion may be given from the data on hair color; after the mother was questioned about hair color she was asked if the reported similarity or difference had been constant since birth. In several cases two children having much the same colored hair at the time of the interview, had at a preceding stage in development differed greatly from each other in hair color. This, of course, was considered confirmatory evidence of dizygosity.

There were some cases (21 of the total 212) in which the worker was in doubt as to the proper classification. These were marked "Undetermined" and have been considered as a separate group. By doing this the other classifications were made more reliable. However, there is at the same time the possibility that the removal of these borderline cases may make the two groups more dissimilar than they really are. This point will be discussed later when the data are compared.

E. DATA OF THE INTERVIEWED GROUP

1. Fairness of Sample

Letters were sent to about 340 parents of the school and preschool groups. This included all the names falling within the prescribed limitations of the desired sample. For various reasons the follow-up

interview was not made in some 128 cases. Different reasons listed were "moved—no address," "on vacation," "both parents working (no time for appointment)," etc. In only four or five cases could the failure be laid to a refusal to coöperate. It is possible that lack of telephone to make appointments, more changes of address, etc., caused homes of the poorer class to be missed more often than those of the higher social groups, but this tendency is probably of no great significance. The sex ratio of the interviewed group (46 per cent were males) was fairly close to the ratio for the like-sexed twins of the whole school and preschool groups where 42 per cent were males. So far as we have been able to determine, the interviewed group (Table 5), represents a fair sample of the total number of twins located.

TABLE 5

Twin Pairs Whose Parents were Interviewed

TYPE OF TWIN	MALE	FEMALE	TOTALS
Identical	37	57	94
Fraternal	49	48	97
Undetermined	11	10	21
Total	97	115	212

2. *Ages of Twins*

Dahlberg (1) gives the average age of his monozygotic group as about 15½ years, and that of his dizygotic group (including unlike-sexed pairs) as about 14 years; the age range was from 3 to 80 years. Computing from the original data for Wingfield's (24) groups we find that the average ages of his identical and fraternal (like-sexed) pairs were 12.0 and 12.25 years respectively. Verschuer's (21) monozygotic group had an average age of 17.67 years and his dizygotic (like-sexed) an age of 12.35 years; the age range was from 3 months to 68 years. In our sample the average age of the monozygotic pairs was greater than that of the dizygotic by about one year. (See Table 6.)

TABLE 6

Age of Twins

TYPE	NO.	RANGE	MEAN	S. D.
Identical	94	1.66-21.42	11.82 ± .24	5.17 ± .17
Fraternal	97	1.42-20.18	10.74 ± .21	4.47 ± .15
Undetermined	21	6.00-19.00	10.98 ± .26	2.52 ± .18

3. Ratio of Identical to Fraternal Pairs

a. Theoretical ratio

Weinberg (22) in 1902 proposed a method for determining the probable number of monozygotic twins born in a given population. His method is as follows:

> Assuming that sex is determined at the time of fertilization and that about half of all zygotes will produce males and the other half females, it follows that there will be equal numbers of same-sexed as opposite-sexed fraternal twins. If, therefore, we double the number of opposite-sexed twins and subtract the product from the total of all twins, the remainder will represent the numbers of monozygotic twins.

Various studies of clinical material (foetal membranes) have very largely confirmed the validity of this theory.[5] When Weinberg's rule is applied,[6] it is found that the proportion of monozygotic births varies considerably both as to time and to place (see Table 7). It is possible that the higher percentage of the monozygotic in the United States, and particularly in California, is the result of a differential change in the pre-natal death rate.

TABLE 7

Percentages of Monozygotic Twins at Birth by Weinberg's Rule

DATA	♂♂	♀♀	♂♀	TOTAL TWIN BIRTHS	% MONOZYGOTIC of all twins	% MONOZYGOTIC of like-sexed
Various European Countries (1902 and before) (13)	234,497	219,312	264,098	717,907	26.4	41.8
Germany (1906-11) (8)	49,425	46,637	58,382	154,444	24.4	39.2
United States (1919-24) (26)	40,231	38,565	40,128	118,924	32.5	49.1
California (1919-23) (26)	1,602	1,591	1,456	4,649	37.4	54.3

b. Ratios in Institute study compared with ratios found by other investigators

Weinberg's method gives the ratio of identical and fraternal pairs that can be expected at birth. It remains to be seen whether or not this ratio keeps constant as the children grow older. The results of a number of investigations are summarized in Table 8. It has been difficult to secure large enough groups to make the obtained ratios statistically reliable, and an additional important factor has been the variation in

[5] Dahlberg (1) ably summarizes and discusses the literature on this subject.

[6] Account must be taken of the sex ratio at birth and the difference between the two sexes in the prevalence of stillbirths.

the criteria used for identification. Merriman (10) states: "Each examiner was asked to report whether the members of the twin pair being studied resembled each other closely enough to frequently cause confusion of identity. Unfortunately not every examiner made this report . . . ." Apparently he obtained this rating on only 67 pairs out of the 131 like-sexed pairs in his sample. Fisher (3) by statistical manipulation of the correlation coefficients for certain anthropometric measurements of Lauterbach's (9) like-sexed twins concludes that "about 59 per cent appear to be identical." Wingfield (24) put in the identical group "only those twins that the examiner and the teachers of the school unanimously agreed upon as identical in physical appearance." The criteria employed by Verschuer (21), Dahlberg (1), and Newman (12) have been previously described and are similar to those used in this study.

TABLE 8

Ratios of Identical and Fraternal Types of Twins Among Like-sexed Pairs

INVESTIGATOR	NUMBER			PER CENTS[1]	
	Ident.	Frat.	Total	Ident.	Frat.
Merriman	22	45	67	33 ± 3.9	67 ± 3.9
Lauterbach & Fisher	..	..	149	59 ± 2.8	41 ± 2.8
Wingfield	45	31	76	59 ± 3.8	41 ± 3.8
Dahlberg	96	95	191	50 ± 2.5	50 ± 2.5
Newman	43	52	95	45 ± 3.5	55 ± 3.5
Verschuer	29	27	56	52 ± 4.5	48 ± 4.5
Institute Sample[2]	94	97	191	49 ± 2.5	51 ± 2.5

[1] Probable errors were determined from tables compiled by Edgerton and Patterson (2).
[2] There were in addition 21 pairs of "undetermined" type.

As shown in the table the results of the different investigations differ considerably. However, where the diagnosis depended on a study of certain selected traits the ratios agree quite closely;[7] the obtained percentages are well within the probable error of their differences. Thus we find—in agreement with other investigators—that in our whole sample of like-sexed twins about one-half of the pairs are of the identical type.

[7] We have assumed here that further study would show our undetermined group to contain about equal numbers of identical and fraternal pairs. However, if they were not thus distributed, but fell all within one group the number of identicals would still be between 45 and 54 per cent of the total number of like-sexed pairs.

c. Ratios by age groups

If, however, we divide our sample into age groups (Table 9) we find that this ratio of identical to fraternal pairs was not uniform throughout the age range. In the group under six years of age about one-half were identical, but in the group of 6 to 13 years 28 per cent were identical as compared with 64 per cent of the 13 year and older group, and the difference is statistically reliable.[8] This difference is, of course, surprisingly high and so far we have been unable to find an adequate reason for it. Following is a consideration of some of the possible causes:

1. The difference might be explained by an unequal distribution of identicals in the undetermined group. However, to bring the percentages within the expected fifty-fifty ratio would require that all of the older undetermined pairs should prove to be of fraternal type and all the younger undetermined prove to be identicals—this, of course, is very improbable.

2. We might assign the difficulty to errors in the diagnosis of type —but this would require that the errors be very numerous and in *opposite directions* for the younger and the older twins. The improbability of this having occurred is heightened by the fact that 93 per cent of the diagnoses of the two older groups were made by the same person.

3. Selective factors affecting the sample must be considered. There is a possibility that in the older groups relatively fewer fraternal pairs were located—because the identicals, being more similar, were more obviously twins; the fraternal because of their dissimilarity were occasionally missed, and the older they were the more chance there was of their twinness remaining unnoticed. As a matter of fact, however, when

TABLE 9

Types of Pairs by Age Groups

AGE	TOTAL NO. BY PAIRS	IDENTICAL No.	IDENTICAL %	FRATERNAL No.	FRATERNAL %	UNDETERMINED No.	UNDETERMINED %
Under 6 yrs.	37	18	49 ± 5.5	19	51 ± 5.5	0	.....
6 to 13 yrs.	102	29	28 ± 3.0	57	56 ± 3.4	16	16 ± 2.5
13 yrs. and over	73	47	64 ± 3.8	21	29 ± 3.6	5	7 ± 2.0

[8] Data from Dahlberg,(1) Verschuer,(21) and Wingfield,(24) show the same tendencies although to a much less degree. In Dahlberg's sample (of like-sexed twins) 43% of the pairs under 13 years were identical as compared with 56%, for pairs 13 years and older. Similar figures for Verschuer's samples were 48% and 54%, and for Wingfield's 59% and 63%.

the population was classified by age, it was found that we had obtained about as full a sample in the older as in the younger ages. The sex ratios also remained approximately constant.

Of course, it is possible that the ratios we found are representative for the various age groups, but this too is very doubtful. There is almost no literature upon the relative death rates of the two types of twins except as regards stillbirths or neonates. On *a priori* grounds it is very improbable that the death rate would be higher for fraternal than for identical pairs, and it is also unlikely that a mortality difference, great enough to account for our results, would have escaped previous observation.

In conclusion, we can only suggest that since no one of the above factors seems sufficient to effect the results obtained, it may be due to a combination of two or more of them plus other possibly chance factors. It may be repeated that when the total group is considered the proportion of identical twins remains close to the theoretical expectation, using Weinberg's rule and the assumption of similar death rates among the two types of twins.

4. Racial Origin of the Parents

Practically all of the parents were born in the United States or in north European countries (see Table 10). For reasons before stated an attempt was made to interview only cases in which both parents were predominantly of north European descent. However, these data could not always be secured from the identification blanks and appointments were made with 13 pairs not coming within this category.[9] In the absence of language handicaps or of other factors which would disturb the comparability of our data, the information received from these interviews was included in the main sample.

5. Social Status of the Parents

As a means of social description of the sample, a rating of home environment was made for each pair. Other workers at the Institute have drawn up and are standardizing a "Berkeley Social Rating Scale." The parts referring to "House Exterior" and "Neighborhood" were used in rating the homes of the twins. Under each of the above characteristics were several subdivisions; these are summed up in a composite

[9] Racial descent of these parents: in two cases, colored; in three cases, South European; in one case, Jewish; in one case, Russian; and in six cases, one parent was German or Scandinavian and the other was Italian, Spanish, or Portuguese.

rating on the basis of a five point scale. As norms for this rating scale have not yet been worked out no comparison can be made with ratings for homes of the single born. However, the distribution of the score is very close to that expected in an unselected sample, on the assumption of a normal distribution curve. The figures show that the various twin groups were very similar in these ratings for "House Exterior" and "Neighborhood." As these two characteristics are highly correlated with other marks of social and economic status we can conclude that the different groups are comparable in this respect.

TABLE 10

Birthplace of Parents

COUNTRY OF BIRTH	PARENTS	IDENTICAL GROUP	FRATERNAL GROUP	UNDETERMINED GROUP	TOTAL
United States	Father	64	73	13	150
	Mother	66	73	13	152
Scandinavian Countries	Father	5	3	3	11
	Mother	4	4	1	9
Great Britain and Colonies	Father	6	14	0	20
	Mother	6	13	1	20
Germany, Austria	Father	6	3	0	9
	Mother	5	2	1	8
Russia, Poland, Finland	Father	2	0	2	4
	Mother	2	0	2	4
Others, and not reported	Father	11	4	3	18
	Mother	11	5	3	19
Totals	Father	94	97	21	212
	Mother	94	97	21	212

TABLE 11

Age, in Years, of Parents at Birth of the Twins

TYPE OF TWIN	NO.[1]	MEDIAN	MEAN	S. D.
Father—				
Identical	80	31.99 ± .45	36.76 ± .36	7.00 ± .25
Fraternal	93	33.08 ± .42	36.26 ± .34	7.12 ± .24
Undetermined	17	34.66 ± .95	33.47 ± .75	7.08 ± .55
Single Born—(Berkeley Survey)	293	32.05	32.58 ± .22	
Mother—				
Identical	81	29.99 ± .40	30.12 ± .32	6.36 ± .22
Fraternal	91	30.50 ± .40	30.04 ± .32	5.72 ± .23
Undetermined	16	30.00 ± .32	30.62 ± .26	2.29 ± .18
Single Born—(Berkeley Survey)	293	28.07	28.81 ± .19	

[1] With data.

6. *Age of Parents*

The average age of the parents at the birth of the twins is shown in Table 11. There is no very significant difference in this respect between the parents of the three groups. The mean age of the fathers was about thirty-six years, while that of the mothers was about thirty years. When compared with the age of the parents of the single-born children studied in the Berkeley survey (see Table 11), we find that the parents of the twins averaged slightly older. This is probably due to the increased ratio of twin births among parents of greater age. (See—*9. Birth Order of Twin Pregnancies.*)

7. *Family Size*

The fertility of twin-bearing parents has been much discussed. Many of the older writers assumed that twinning was correlated with increased fertility. However, Dahlberg (1) after reviewing the literature states that "an increase of the relative fertility in twin-bearing mothers is not statistically proved, and the results of investigations rather speak against the existence of such an increase." In the families from which our twins were drawn the number of children per family is represented by a mean of 3.94 with an S. D. of 1.89.[10] In other words, each pair of twins had, on the average, 1.94 single born sibs. There is no significant difference between the identical and fraternal groups in this respect.

In another study at the Institute, data were secured concerning the sibs of 1,037 representative school children of Berkeley. If we segregate from our sample the twin pairs of the same age range (9 through 14 years), we have a group that is comparable with the Berkeley children. The averages of the two groups were as follows:

Mean number of sibs of Berkeley single births:—
1.96 ± .04 with S. D. of 1.61
Mean number of sibs of twin births:—
1.83 ± .12 with S. D. of 1.62

The difference between the two is not statistically reliable.

The distribution of family size is shown in the following table where the number of sibs per individual, or twin pair is given in per cent:

[10] The data presumably include all living births; no attempt was made to secure data on miscarriages, abortions, or stillbirths.

e. g., 15.5 per cent of the Berkeley children and 17.8 per cent of the twin pairs had no siblings.

TABLE 12

Siblings of Twins and "Normal" Children

NUMBER OF SIBS	0	1	2	3	4	5	6	7	8	9
Berkeley Single Births	15.6	29.7	25.4	14.9	6.2	3.9	2.2	.8	.7	.2
Twin Births	17.8	36.7	18.9	12.2	5.6	5.6	1.1	2.2	0	0

From these data we must conclude that the mothers of the twins had about the same number of fruitful pregnancies as the mothers of single born; that the twin families were larger was due solely to the fact that some of the pregnancies were double.

8. Percentage of Plural Births in Family

We secured data on the number of children in 203 families. Three of these families had two pairs of twins each. In one case the second pair, girls, had died at birth, in the other two cases the second pair were of unlike-sex. One family included in the survey had three pairs of twins (besides three other children). Two of these pairs were of unlike-sex. Adding these five extra pairs of twins to the 203 pairs included in the investigation makes a total of 208 pairs. As there were 598 births [11] in the families from which the sample is taken it follows that 34.8 per cent of the fruitful pregnancies resulted in the birth of twins.

9. Birth Order of Twin Pregnancies

Birth records show that there is a positive correlation between the proportion of twin births and the number of pregnancies of the mother. But as it is also known that older mothers tend to have a higher proportion of twins, it is difficult to segregate the two factors. The increase with pregnancies may be due to the age factor alone as, of course, the average age of mothers is less at early pregnancies than it is at later ones. In studies of birth statistics of the Registration Area of the United States for 1924 (26), the mothers have been separated into five age groups. In each group, the percentage of twin births increased markedly and regularly with the increase in pregnancy number. For example, in the mothers of 30-34 years the rate per thousand births is 11.6 at first pregnancy, 12.8 at second, 13.7 at third, 15.3 at fourth, with a similar

[11] In this case the delivery of twins is considered as one birth. Data upon the incidence of twins among relatives of the present sample are given by Wilson (28) in another paper.

increase until at the tenth pregnancy the rate is 24.2 per thousand. However, it may be that this apparent increase is simply due to a displacement within each group. In Australian statistics the twin frequency is given by each year of age of the mother. Dahlberg (1) using these figures concludes that "the number of preceding births does not influence twin frequency."

At the interviews, data were secured concerning the birth order of the twins as well as the total number of children in the family. This information is summarized in the following table:

TABLE 13

Birth Order of Twin Pregnancies

(Percentages are computed only for the larger numbers)

BIRTH ORDER	IDENTICAL (90 prs. with data)			FRATERNAL (94 prs. with data)			UNDETERMINED (19 prs. with data)			ALL TYPES (203 prs. with data)		
	Total No. Pregnancies	No. Twin Pregnancies	% Twin Pregnancies	Total No. Pregnancies	No. Twin Pregnancies	% Twin Pregnancies	Total No. Pregnancies	No. Twin Pregnancies	% Twin Pregnancies	Total No. Pregnancies	No. Twin Pregnancies	% Twin Pregnancies
1st	89	25	28.1	93	29	31.2	19	5	..	201	59	29.4
2nd	75	27	36.0	74	33	44.6	15	9	..	164	69	42.1
3rd	51	24	47.1	42	14	33.3	7	1	..	100	39	39.0
4th	22	7	...	22	9	...	7	1	..	51	17	33.3
5th	16	4	...	12	2	...	7	1	..	35	7	20.0
6th	8	2	...	7	5	...	4	0	..	19	7	...
7th	3	0	...	5	0	...	3	0	..	11	0	...
8th	1	0	...	3	1	...	3	1	..	7	2	...
9th	1	0	...	2	1	...	3	0	..	6	1	...
10th	1	1	...	0	0	...	2	0	..	3	1	...
11th	0	0	...	0	0	...	1	1	..	1	1	...
Total	267	90	...	260	94	...	71	19	..	598	203	...

In all three groups the percentage of twins born at the first pregnancy is surprisingly low, yet in no case is the difference between percentages statistically reliable. In all types combined 29.4 per cent of the first pregnancies resulted in the birth of twins as compared with 42.1 per cent of the second pregnancies. (Difference 12.7 ± 3.4)

10. Length of Pregnancy

To secure this information the mothers were asked, "What was the length of the pregnancy? Were the babies born at the time expected?" Usually such answers were received as: "born at eight months," "two

weeks short," "a week overtime," "about at term." The accuracy of such data is, of course, in considerable doubt, but there appears to be no reason to suspect the comparability of the records for the different groups of twins. A difference in central tendency between the identicals and fraternals might be significant even though the individual reports are of low validity. As a matter of fact, in the following table (No. 14), a shorter average term appears to be indicated for the identicals.[12]

TABLE 14

Length of Pregnancy

TYPE	TOTAL NO. ANSWERS	BORN "BEFORE EXPECTED"			BORN "LATER THAN EXPECTED"		
		No.	Per cent	Av. time	No.	Per cent	Av. time
Identical	80	34	42.5 ± 3.7	.93 months	3	3.8 ± 1.5	.33 months
Fraternal	81	22	27.0 ± 3.0	.72 months	7	8.6 ± 2.2	.53 months
Undetermined	15	6	40.0	1.05 months	1		.25 months

If this is true, a possible inference may be that parturition is hastened by the more abnormal conditions contingent upon single placentation. Such an inference, however, would need to be considered in relation to possible differences between identicals and fraternals in abortions, stillbirths, and infant mortality.

11. Health of Mother and Ease of Delivery

Mothers who had borne single children were able to make a comparison between the difficulty of pregnancy and of delivery in the case of the single children as compared with the twins. So far as is indicated by their testimony, no significant differences appeared, other than those related to carrying a greater weight and of slightly more difficult afterbirth when two foetal membranes were involved. The use of instruments was of about the same frequency for twins as for other children, with no significant difference between the identical and fraternal groups. In the undetermined group, however, an exceptionally large percentage of mothers complained of difficult deliveries. In view of the small number of cases, this may be merely a chance phenomenon. It is hoped that a further study of individual cases may throw more light upon the relationship of pre-natal and neo-natal factors to the later developmental characteristics of twins.

[12] There was no significant difference between the boy and the girl pairs.

12. Foetal Membranes

Accurate data concerning the foetal membranes of a pair of twins would be exceedingly valuable evidence in determining their type. As we had hoped to use such data, particular care was taken to secure as much and as reliable information as was possible. The better informed mothers were questioned about the chorion and placenta; others were asked if there were one or two after-births or sacs that had held the babies. Although most of the women questioned were entirely coöperative, it was found impossible to get much reliable information. The difficulty was largely due to the mother's ignorance of the function and significance of the membranes.

13. Weights at Birth

Robertson (15) has assembled figures on the birth weight of children. Using data from England, United States, Germany, Denmark, and Australia he shows that the average birth weight in pounds varies from 7.18 to 7.96 for males and 7.08 to 7.58 for females. However, there are very few reports upon the average weights of twins at birth and even fewer instances where the twins have been divided into identical and fraternal groups. Miller (11), in his report on 3,883 pairs, gave the average weight at birth, of the individual twin, as 4.82 pounds (2,190 grams) for the male and 3.89 pounds (1,770 grams) for the female. These very low averages may possibly be due to the type of population he was dealing with, his data being secured from a charity hospital in the poorer part of Moscow.

TABLE 15

Weights and Intra-pair Differences in Weights of Twins at Birth (expressed in pounds)

TYPE OF PAIR	NO. (pairs)	MEAN WEIGHT OF INDIVIDUALS	INTRA-PAIR DIFFERENCES		
			MEDIAN	MEAN	S. D.
A. Dahlberg's					
Identical	59	5.11		.78	
Fraternal	207	5.29		.46	
B. Institute Sample					
Identical	88	6.00 ± .05	.55 ± .05	.72 ± .04	.70 ± .03
Fraternal	92	6.13 ± .05	.69 ± .05	.98 ± .04	.87 ± .03
Undetermined	18	6.04 ± .13	.63 ± .12	.73 ± .09	.85 ± .07

Silberstein (18), Rabinowitsch (14), Hust (7), and Tauber (19) have given figures of birth weight in which the identical and fraternal twins have been kept separate. Dahlberg (1) has recompiled these data with all cases of stillborn sorted out (Table 15). His tables give the weights by months of pregnancy—those born at seven months, at eight months, etc. When these figures are combined we get the following: In 59 pairs of identicals the average weight of the individual is 5.11 pounds; in 207 pairs of fraternals the weight is 5.29 pounds.

The birth weight data for the different groups in our survey are summarized in the following table:

TABLE 16
Weights at Birth

	NO. (Individuals)	MEDIAN	MEAN	S. D.
Identical	176	6.02 ± .06	6.00 ± .05	1.40 ± .03
Fraternal	184	6.30 ± .06	6.13 ± .05	1.45 ± .03
Undetermined	36	6.50 ± .16	6.04 ± .13	1.69 ± .09
Male	182	6.40 ± .06	6.27 ± .05	1.35 ± .03
Female	214	5.95 ± .06	5.89 ± .05	1.50 ± .03
First-born[1]	191	6.13 ± .06	6.02 ± .05	1.45 ± .03
Second-born	191	6.31 ± .06	6.16 ± .05	1.48 ± .03
Combined	396	6.21 ± .04	6.00 ± .03	1.45 ± .02

[1] Seven cases of Caesarian birth omitted.

There was no reliable difference in the mean weights between identical and fraternal, nor between first-born and second-born; the males weighed slightly more than the females. The mean weight of the individuals of all groups (6.00 ± .05 lbs.) is considerably higher than that noted by Dahlberg (see Table 15). However, it must be borne in mind that our figures represent the birth weights of twin pairs who have survived to an average age of ten years or more. It is very probable that the infants who are heavier at birth have a greater chance of surviving. In this case, a population of the ages here studied would be largely selected from such children.

14. Intra-pair Differences in Weights at Birth

The weight of a child at birth is dependent upon many factors. These would include nutritive and other environmental conditions within the uterus, length of time of development and the hereditary factors for

size. All of these factors may differ for the two members of a pair of fraternal twins, and for the identical all may differ except the hereditary make-up, which is assumed to be the same. (It is improbable that the reversed asymmetry phenomena would play much part in causing intra-pair differences in weight.) However, many investigators have found that there is often a very great difference in birth weights between the two members of a monozygotic pair.

Some authors claim that there is usually more intra-pair difference between identical twins than between fraternal. Dahlberg, in the same table he compiled for average birth weights, gives the average intra-pair difference in weight for the two types. Our findings differ from his considerably as is shown in Table 15. In our sample, the fraternal showed more intra-pair differences than the identical; this group was also more variable in these differences.

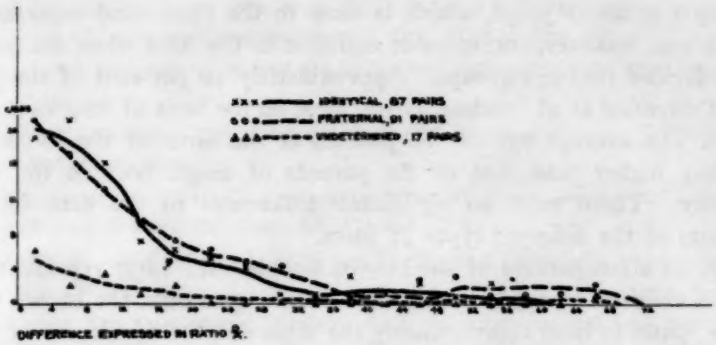
There is, however, one important criticism of this method of computing intra-pair difference in weight in that no account is taken of the total weight of a pair. One pound difference in a pair of twins with a combined weight of eight pounds is hardly comparable with a like difference in a pair weighing fifteen pounds. To allow for this factor, we used the following method in computing the intra-pair differences: The difference between the weight of the two members of a pair was divided by the average weight of the pair and this ratio, $\frac{D}{A}$, expressed in per cent, is used as a measure of intra-pair difference.

TABLE 17

Intra-pair Differences in Weight at Birth, Expressed as a Percentage of the Average Weight of Each Pair. (See also Graph I, with explanation)

TYPE OF TWIN	NUMBER PRS. WITH DATA	MEDIAN DIFFERENCE	MEAN DIFFERENCE	S. D. OF DIFFERENCE
Identical	88	9.00 ± .75	12.76 ± .57	11.72 ± .40
Fraternal	92	10.90 ± .95	16.28 ± .75	16.40 ± .60
Undetermined	18	9.33 ± 2.20	13.76 ± 1.80	16.40 ± 1.60

Table 17 shows the result of this computation and the data are expressed graphically in Graph I. There is apparently no very significant difference between the groups; the mean for the fraternals is higher, but the differences between the means are not statistically reliable.



GRAPH I.—A comparison of intra-pair differences in weight at birth; see Table 10. The difference in weight between the two members of each pair was divided by the average weight of the two. The numbers along the abscissa represent this ratio expressed in per cent; the numbers on the ordinate represent the number of cases. The following is an example of the method used: Weight of 1st twin is 7 lbs., weight of 2nd twin is 6 lbs. The average (A) would be 6.5, the difference (D) 1.0, $\frac{D}{A} = \frac{1.0}{6.5}$ or 15.38%. If there were 4 such cases they would be plotted at P.

F. SUMMARY

1. A census was made of the twins in four school systems, totalling 75,000 enrollment. The total number of individual twins located (1,051) was close to the number expected on the basis of U. S. census data for plural births, a correction being made for differential death rate.

2. Of 471 pairs with both members living, 28 per cent were male, 39 per cent female and 33 per cent mixed. The comparable figures for 860 pairs in five other investigations are 30, 40, and 30.

3. In addition to the school twins, the survey located 115 preschool pairs and 144 adult pairs of twins. These showed approximately the same sex ratios, except for a smaller proportion of unlike-sex pairs.

4. A sub-sample was selected for further study of developmental and familial characteristics. This group consisted of like-sexed twins of school and preschool age, whose parents were of the white race and born in the United States or northern Europe. Data from 212 pairs were secured by means of a standardized interview with the mothers. The pairs were classified as of identical, fraternal, or undetermined type and the characteristics of each group studied.

5. The ratio of identical to fraternal pairs in the whole interviewed

group was about 50:50, which is close to the theoretical expectation; there was, however, considerable variation in the ratio when the sample was divided into age groups. Approximately 10 per cent of the pairs were classified as of "undetermined" type on the basis of interview data.

6. The average age of the parents at the birth of the twins was slightly higher than that of the parents of single born in the same locality. There were no significant differences in the data for the parents of the different types of pairs.

7. In a comparison of the known sample with 1,037 representative school children of single births, of the same age range, the known pairs were found to have approximately the same number of sibs as the children of single births. In other words, mothers bearing twins had only an average fertility in terms of number of pregnancies.

8. In the families interviewed about one-third of the fruitful pregnancies resulted in the birth of twins.

9. In conformity with previous findings, there was an apparent tendency for relatively few twins to be born at the first pregnancy.

10. More identical than fraternal twins were "born before expected" but the data were too meager to be more than suggestive.

11. From the testimony of the mothers there is no evidence of more difficulty during pregnancy and delivery of twins, than during pregnancy and delivery of single born children.

12. Interview data concerning foetal membranes failed to give dependable results.

13. The average weight at birth of the individual twins was about six pounds. There was no reliable difference between the identical and fraternal, nor between the first-born and second-born; the usual sex difference was found, the males weighing more than the females.

14. When the identical and fraternal groups were compared for intra-pair differences in birth weight (in pounds), the fraternals showed a greater average difference, and their differences were more variable. These results, however, were not confirmed when the intra-pair differences were computed in relation to the total weight of each pair.

LITERATURE CITED

1. DAHLBERG, G. 1926. Twin births and twins from a hereditary point of view. *Stockholm.*

2. EDGERTON, H. A., and PATTERSON, D. G. 1926. Table of standard errors and probable errors of percentages for varying numbers of cases. *Jour. Psych.*, X, No. 3, p. 378.

3. FISHER, R. A. 1925. The resemblance between twins, a statistical examination of Lauterbach's measurements. *Gen.*, X, No. 6, p. 569.

4. GALTON, F. 1883. Inquiries into Human Faculty and Its Developments. *London.*

5. GESELL, A. 1922. Mental and physical correspondence in twins. *Sci. Monthly*, April-May, 1922.

6. HOLZINGER, K. J. 1929. The relative effect of nature and nurture influences on twin differences. *Jour. Ed. Psychol.*, XX, 4.

7. HUST, W. 1916. Über 100 Fälle von Zwillingsschwangerschaft und geburten. Diss. *Würtzburg.*

8. KNIBBS, G. 1925. Multiple births, their characteristics and laws mathematically considered. *Jour. and Proc. R. Soc. of N. S. W.*, LIX, p. 128.

9. LAUTERBACH, C. E. 1925. Studies in twin resemblances. *Gen.*, Vol. X, No. 6, p. 525.

10. MERRIMAN, C. 1924. The intellectual resemblance of twins. *Psych. Mon.*, Vol. XXXIII, No. 5.

11. MILLER, N. 1893. Über homologe Zwillinge. *Jahrbuch Kinderheilkunde*, XXXVI, p. 333.

12. NEWMAN. 1928. Studies of human twins: I. Methods of diagnosing monozygotic and dizygotic twins. *Bio. Bull.*, Vol. LV, No. 4, p. 283.

13. NICHOLS, J. B. 1907. The numerical proportions of the sexes at birth. *Memoirs of Am. Anthr. Ass.*, I.

14. RABINOWITSCH, C. 1913. Über Zwillingsgeburten des Basler Frauenspitales für die Zeit 1896-1910.

15. ROBERTSON, T. B. 1923. Growth and Development. Abt's Pediatrics, Vol. I. W. B. Saunders Co.

16. SIEMENS, H. W. 1925. Die Diagnose der Eineiigkeit in geburtshilflicher und in dermatologischer Betrachtung. *Arch. Gyn.*, p. 126.

17. ———. 1927. The diagnosis of identity in twins. *Jour. Her.*, Vol. XVIII, No. 5.

18. SILBERSTEIN, M. 1907. Die Zwillingsgeburten der Breslauer Universitäts Frauenklinik von 1902-1906. Diss. *Breslau.*

19. TAUBER, H. 1916. Über 100 Fälle von Zwillingsschwangerschaft und geburten. Diss. *Jena.*

20. THORNDIKE, E. L. 1905. Measurement of twins. *Arch. of Phil., Psych., and Sci. Methods*, No. 1.

21. VERSCHUER, O. VON. 1927. Der vererbungsbiologische Zwillingsforschung. *Ergeb. Inneren. Med. u. Kinderheit*, Bd. 31.

22. WEINBERG, W. 1902. Probleme der Mehrlingsgeburtenstatistik. *Zeitschr. f. Geburtsh. u. Gynäk.*, Bd. 47.

23. WESTERGAARDE, H. 1891-92. Zur Statistik der Mehrgeburten. *Allgm. Statistickes Arch.*, Bd. 2.

24. WINGFIELD, A. H., and SANDIFORD, P. 1928. Twins and orphans. *Jour. Ed. Psych.*, Vol. XIX, No. 6, p. 410.

25. WINGFIELD, A. H. 1928. Twins and orphans; the inheritance of intelligence. *London* and *Toronto*.

26. BIRTH, STILLBIRTH and Infant Mortality Statistics for the Birth Registration Area of the United States. Years 1915 to 1925.

27. FOURTEENTH CENSUS of the United States, 1920, Vol. II.

28. WILSON, P. T. 1930. A study of like-sexed twins. III. Twinning among relatives. *Jour. Her.*, Vol. XXI, No. 5, pp. 371-374.

NOTES

LONGEVITY: A PEDIGREE[1]

The accompanying pedigree (Fig. 1) is noteworthy for two things; first, because it is extremely unusual to find both husband and wife living at such advanced ages as 96 years; and, second, because of the high incidence of great longevity in this family group as a whole. This latter point may perhaps be brought more strikingly home to the mind by recalling that, on the average, only about 14 persons in a hundred born reach the age of 80; only 6 in a hundred born reach the age of 85; a fraction less than 2 in a hundred the age of 90; and only about 4 persons in a *thousand* reach the age of 95.

In the present chart ♂ denotes a male and ♀ a female. The figures within the circle of a sex sign indicate the age at which that individual died, except in those cases which have the letters *Liv.* below, where the figures indicate the age at the time of the report (1926), when the person was still living. The Roman numerals indicate generations. The figures below the sex sign denote the number of the individual in the pedigree, in lieu of the name.

The chief characteristics of Nos. 17 and 18 may be summarized as follows:

No. 17 was born July 14, 1830, and was therefore at the date of the report (December 6, 1926) 96 years, 145 days of age. Height 5 ft. 11 in. Average weight 135 pounds, which has changed but little since the age of 25. Hair color (at age 25), brown; eye color, blue; blonde. He is of English racial stock. His active life has been spent as a clerk and bank cashier. He has never engaged in heavy manual labor. He was born in a city, and has always lived in cities. His health has always been fairly good. He has never had a surgical operation. He has had measles, whooping cough, and typhoid fever, but never scarlet fever, diphtheria, malaria, pneumonia, or other serious illness. Twenty-five years ago (i. e., at about the age of 71) he developed a hernia and has since worn a truss. Has "always been a temperate user of whiskey,

[1] From the Department of Biology of the School of Hygiene and Public Health of the Johns Hopkins University.

PEDIGREE CHART 871

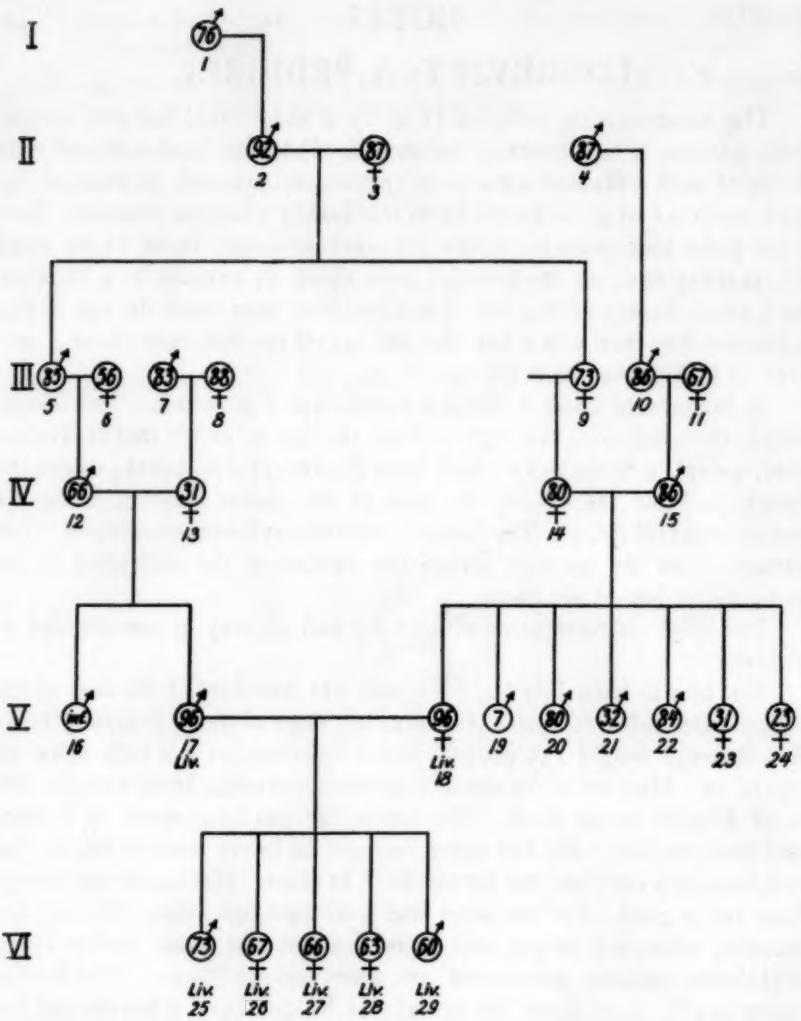


FIG. 1. PEDIGREE SHOWING FAMILIAL LONGEVITY

wine and beer." Since 1900 has used whiskey only occasionally, seldom as a beverage. For 12 to 15 years in early life he smoked cigars, but for the last 50 years has used no tobacco.

No. 18, the consort and also the second cousin of No. 17, was born April 26, 1831. She was therefore 95 years, 224 days of age on the date of the report. Height, 5 ft. 4 in. Average weight 130 pounds. Hair color (at 25 years of age), black; eye color, brown; brunette. She is of English racial stock. She was born in a city and has always lived in cities. Her health has never been very good. She had in early life measles, whooping cough, and malaria, but never scarlet fever or diphtheria. At the age of 81 her right hip was broken, at 90 she had a serious illness from pleurisy, and at 93 another serious illness from a carbuncle. She has never had a surgical operation. She has never used tobacco and only "very little" alcohol. She states that her life has been spent quietly "raising my children and attending to my household duties."

No. 17 and No. 18 were married on November 18, 1851, and celebrated the *seventy-eighth* anniversary of their marriage in 1929, each being then approximately 99 years of age.

This marriage produced five children. From these there have been produced 16 grandchildren (of whom 14 are living), and 17 great-grandchildren.

At the time of the report all of the five children were living at the ages indicated on the pedigree. This sibship of generation VI has the following biometric characteristics, as of the year 1926:

Mean age (*living*)	$= 65.8 \pm 2.0$ years
Standard deviation	$= 4.4 \pm 1.0$ years
Coefficient of variation	$= 6.6 \pm 1.6$ per cent.

Since these five persons are all living, it is appropriate to compare their biometric constants with those of the living population in 1920, of the State in which they were born and have mainly lived.

Mean age of living population [2] of Georgia (1920)	$= 24.982 \pm .010$ years
Standard deviation	$= 18.834 \pm .007$ years
Coefficient of variation	$= 75.39 \pm .04$ per cent

It seems evident that the individuals of generation VI of Pedigree No. 871 cannot reasonably be looked upon as a random sample, in

[2] Native white of native parentage.

respect of age, of the total living population in the same general geographical and climatic environment. This sibship has an average living age 40.8 years *greater* than that of a comparable living general population, and a very much lower variation. Glover's Life Tables (p. 55) show that the expectation of life (mean after-life-time) of a group of persons including both sexes (as of 1910) between 65 and 66 years of age is 11.60 years. Hence it may be expected that this group of five sibs, if they die, from the time of the record on, in the same manner as the general population relative to age, will have an average age at death of about 77 years.

The pedigree records 17 direct ancestors of the sibship constituting generation VI of the pedigree. Of these 15 are dead and two living. The biometric characteristics of this ancestral group are given below, including the two living parents with the 15 dead ancestors, on the ground that, whenever Nos. 17 and 18 may die, the value of the ancestral mean cannot possibly be *lower* than that given below, nor the value of the standard deviation more than slightly higher. The 17 direct ancestors had lived a total of 1,335 years up to the time of the record.

Seventeen Direct Ancestors of Generation VI

Mean age	$= 78.5 \pm 2.9$ years
Standard deviation	$= 15.9 \pm 1.9$ years
Coefficient of variation	$= 20.2 \pm 2.5$ per cent

These figures may be compared with the corresponding constants for age at death of all persons dying at age 30 and above in the United States Registration Area during the five years 1923-27 inclusive.

Deaths at age 30 and above of native whites in the United States Registration Area, 1923-27 inclusive

Mean age	$= 63.183 \pm .007$ years
Standard deviation	$= 15.509 \pm .005$ years
Coefficient of variation	$= 24.545 \pm .008$ per cent

From this comparison it appears that the direct ancestors of the sibship of generation VI of the pedigree died (or will die) at an average age 15+ years greater than that of the corresponding part of the general population. This is a difference of about 24 per cent. This difference may be looked upon as a rough index of the degree of selection for

longevity[8] which has occurred in the ancestry of the sibship of generation VI of the pedigree.

The sibship to which No. 18 belongs had seven members. They plainly break up into two differentiated groups in respect of duration of life. One group, consisting of four persons (Nos. 19, 21, 23, and 24) was short lived, with an average age at death of 23.25 years. Three of them died of tuberculosis and one of scarlet fever. The other three in the sibship (Nos. 18, 20, 22) were long lived, the average number of years lived by these three being 86.67 years.

From these facts a bold and reckless speculator might easily formulate a Mendelian scheme to rationalize the incidence of different degrees of life duration in this case. It would seem, however, that such an enterprise could hardly be regarded as falling within what the Census Bureau, in a slightly different sense to be sure, calls a "gainful occupation."

Finally it may be said that the greatest care has been taken to authenticate the records of ages in the pedigree, and it is believed that they are correct. It will be noted in this connection that there is no record of a centenarian in this family, though Nos. 17 and 18 were, when last heard from in 1929, getting close to the 100 year mark.

RAYMOND PEARL.

[8] Or, more precisely, of the degree of differentiation of the ancestry from the general population in respect of longevity.

QUOTATIONS

HARVEY'S POST-MORTEM EXAMINATION OF THOMAS PARR

There have been recorded but relatively few systematic post-mortem examinations of centenarians. Professor George Rolleston[1] published an autopsy of a man, John Pratt, reputed to have been 106 years old at the time of his death, and in the course of this interesting paper gave a rather full abstract of Berruti's autopsy of the Italian priest who died at the reputed age of 104, and briefer notes on the post-mortem examination of Dr. Holyoke. Keill reported in 1706 on the condition of the body of one John Bayles supposed—probably quite erroneously—to have been 130 years old at death. Haller described in 1747 an autopsy of a woman reputed to have been a centenarian.

There have been other similar records, but easily the most famous of all is William Harvey's "Anatomical Examination of the Body of Thomas Parr who died at the Age of One Hundred and Fifty-two Years," etc. To the popular fancy nothing could be more fitting than to have one of the oldest men who ever lived autopsied by one of the greatest of all physicians.

Before proceeding to the quotation of Harvey's account, however, it will be well to examine briefly the evidence about Parr's age. For many years it was generally accepted that he was 152 years and nine months old at the time of his death, chiefly because Harvey had said so, and, even more convincing to the popular mind, because it said so on his tombstone in Westminster Abbey. Young[2] (pp. 24 and 25) says:

> Thomas Parr appears undoubtedly to have been an extremely aged man, of probably 100 years of age, and possibly one or two years more; especially as the autopsy by the distinguished Physician, William Harvey (the discoverer of the

[1] Rolleston, G. Scientific Papers and Addresses. Edited by William Turner. Oxford (Clarendon Press), 1884. Vol. I, pp. 141-154.

[2] Young, T. E. On Centenarians; and the Duration of the Human Race. A Fresh and Authentic Enquiry; with Historical Notes, Criticisms, and Speculations. A Re-issue with Seven Additional Authenticated Instances of Centenarians, and Further Observations. London (C. and E. Layton), 1905. Pp. viii + 147 + 2 unnumbered.

circulation of the blood), confirmed the *general* statement of his advanced age. He is supposed to have been born at Winnington, in the Parish of Alderbury, in 1483, while his death is recorded on the 14th of November, 1635. If these dates could be attested, his age at death would be 152 years 9 months and a few days. His reputation for extreme age depends exclusively upon his own assertion, and upon the lucubrations of John Taylor, who published a metrical (and doggerel) history of Parr in 1635, though, unhappily, Taylor furnishes no facts or figures of any description, proved or capable of proof, of the statements which his rude verses contain. Mr. Thoms had searches instituted in the Diocesan records at Hereford, and made numberless efforts, by means of direct enquiries and advertisements, to obtain some fragment of substantiation; but no corroborative information could be elicited beyond the entry of his year of death. The Registers of Alderbury contain no mention of him. The record of Parr's age, Mr. Thoms has no difficulty in showing, rests exclusively, as in the case of Jenkins, upon the man's own unsupported personal assertions.

Parr, therefore, may be relegated, with Jenkins, without the faintest misgiving, to the voluminous roll of reputed Centenarians in excess which common rumour and the popular love of the marvellous have produced.

Exactly the same conclusions regarding Thomas Parr's age were reached by Thoms[3] (pp. 85-94).

The quotation which follows is from the Sydenham Society edition of Harvey's works, translated by Robert Willis. Harvey's original account first appeared in the treatise of Dr. Bett entitled *"De Ortu et Natura Sanguinis,"* 8 vo. London, 1669. The manuscript had been presented to Bett by Harvey's nephew, Mr. Michael Harvey. Harvey's account is reproduced in full in the following quotation.

THE ANATOMICAL EXAMINATION
OF THE BODY OF
THOMAS PARR,
WHO DIED AT THE AGE OF ONE HUNDRED AND FIFTY-TWO YEARS;
MADE BY
WILLIAM HARVEY,
OTHERS OF THE KING'S PHYSICIANS BEING PRESENT,
ON THE 16TH OF NOVEMBER, THE ANNIVERSARY OF THE BIRTHDAY
OF HER SERENE HIGHNESS
HENRIETTA MARIA, QUEEN OF GREAT BRITAIN, FRANCE AND IRELAND.

THOMAS PARR, a poor countryman, born near Winnington, in the county of Salop, died on the 14th of November, in the year of grace 1635, after having lived

[3] Thoms, W. J. Human Longevity, its Facts and its Fictions including an Inquiry into some of the more Remarkable Instances, and Suggestions for Testing Reputed Cases. Illustrated by Examples. London (John Murray), 1873. Pp. xii + 320.

one hundred and fifty-two years and nine months, and survived nine princes. This poor man, having been visited by the illustrious Earl of Arundel when he chanced to have business in these parts, (his lordship being moved to the visit by the fame of a thing so incredible,) was brought by him from the country to London; and, having been most kindly treated by the earl both on the journey and during a residence in his own house, was presented as a remarkable sight to his Majesty the King.

Having made an examination of the body of this aged individual, by command of his Majesty, several of whose principal physicians were present, the following particulars were noted:

The body was muscular, the chest hairy, and the hair on the fore-arms still black; the legs, however, were without hair, and smooth.

The organs of generation were healthy, the penis neither retracted nor extenuated, nor the scrotum filled with any serous infiltration, as happens so commonly among the decrepid; the testes, too, were sound and large; so that it seemed not improbable that the common report was true, viz. that he did public penance under a conviction for incontinence, after he had passed his hundredth year; and his wife, whom he had married as a widow in his hundred-and-twentieth year, did not deny that he had intercourse with her after the manner of other husbands with their wives, nor until about twelve years back had he ceased to embrace her frequently.

The chest was broad and ample; the lungs, nowise fungous, adhered, especially on the right side, by fibrous bands to the ribs. They were much loaded with blood, as we find them in cases of peripneumony, so that until the blood was squeezed out they looked rather blackish. Shortly before his death I had observed that the face was livid, and he suffered from difficult breathing and orthopnœa. This was the reason why the axillæ and chest continued to retain their heat long after his death; this and other signs that present themselves in cases of death from suffocation were observed in the body.

We judged, indeed, that he had died suffocated, through inability to breathe, and this view was confirmed by all the physicians present, and reported to the King. When the blood was expressed, and the lungs were wiped, their substance was beheld of a white and almost milky hue.

The heart was large, and thick, and fibrous, and contained a considerable quantity of adhering fat, both in its circumference and over its septum. The blood in the heart, of a black colour, was dilute, and scarcely coagulated; in the right ventricle alone some small clots were discovered.

In raising the sternum, the cartilages of the ribs were not found harder or converted into bone in any greater degree than they are in ordinary men; on the contrary, they were soft and flexible.

The intestines were perfectly sound, fleshy, and strong, and so was the stomach; the small intestines presented several constrictions, like rings, and were muscular. Whence it came that, by day or night, observing no rules or regular times for eating, he was ready to discuss any kind of eatable that was at hand; his ordinary diet consisting of sub-rancid cheese, and milk in every form, coarse and hard bread, and small drink, generally sour whey. On this sorry fare, but living in his home, free from care, did this poor man attain to such length of days. He even ate something about midnight shortly before his death.

The kidneys were bedded in fat, and in themselves sufficiently healthy; on their anterior aspects, however, they contained several small watery abscesses or serous collections, one of which, the size of a hen's egg, containing a yellow fluid in a proper cyst, had made a rounded depression in the substance of the kidney. To this some were disposed to ascribe the suppression of urine under which the old man had laboured shortly before his death; whilst others, and with greater show of likelihood, ascribed it to the great regurgitation of serum upon the lungs.

There was no appearance of stone either in the kidneys or bladder.

The mesentery was loaded with fat, and the colon, with the omentum, which was likewise fat, was attached to the liver, near the fundus of the gall-bladder; in like manner the colon was adherent from this point posteriorly with the peritoneum.

The viscera were healthy; they only looked somewhat white externally, as they would have done had they been parboiled; internally they were (like the blood,) of the colour of dark gore.

The spleen was very small, scarcely equalling one of the kidneys in size.

All the internal parts, in a word, appeared so healthy, that had nothing happened to interfere with the old man's habits of life, he might perhaps have escaped paying the debt due to nature for some little time longer.

The cause of death seemed fairly referrible to a sudden change in the non-naturals, the chief mischief being connected with the change of air, which through the whole course of life had been inhaled of perfect purity,—light, cool, and mobile, whereby the præcordia and lungs were more freely ventilated and cooled; but in this great advantage, in this grand cherisher of life this city is especially destitute; a city whose grand characteristic is an immense concourse of men and animals, and where ditches abound, and filth and offal lie scattered about, to say nothing of the smoke engendered by the general use of sulphureous coal as fuel, whereby the air is at all times rendered heavy, but much more so in the autumn than at any other season. Such an atmosphere could not have been found otherwise than insalubrious to one coming from the open, sunny and healthy region of Salop; it must have been especially so to one already aged and infirm.

And then for one hitherto used to live on food unvaried in kind, and very simple in its nature, to be set at a table loaded with variety of viands, and tempted not only to eat more than wont, but to partake of strong drink, it must needs fall out that the functions of all the natural organs would become deranged. Whence the stomach at length failing, and the excretions long retained, the work of concoction proceeding languidly, the liver getting loaded, the blood stagnating in the veins, the spirits frozen, the heart, the source of life, oppressed, the lungs infarcted, and made impervious to the ambient air, the general habit rendered more compact, so that it could no longer exhale or perspire—no wonder that the soul, little content with such a prison, took its flight.

The brain was healthy, very firm and hard to the touch; hence, shortly before his death, although he had been blind for twenty years, he heard extremely well, understood all that was said to him, answered immediately to questions, and had perfect apprehension of any matter in hand; he was also accustomed to walk about, slightly supported between two persons. His memory, however, was greatly impaired, so that he scarcely recollected anything of what had happened to him when he was a young man, nothing of public incidents, or of the kings or nobles who had

made a figure, or of the wars or troubles of his earlier life, or of the manners of society, or of the prices of things—in a word, of any of the ordinary incidents which men are wont to retain in their memories. He only recollected the events of the last few years. Nevertheless, he was accustomed, even in his hundred and thirtieth year, to engage lustily in every kind of agricultural labour, whereby he earned his bread, and he had even then the strength required to thrash the corn.

R. P.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Raymond Pearl, Department of Biology, School of Hygiene and Public Health, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

I. EVOLUTION AND GENETICS

BATESON, W. Mendel's Principles of Heredity. *New York* (The Macmillan Co.), 1930. Pp. xiv + 413. 6 × 9 inches. $5.00.

BAUR, ERWIN. Einführung in die Vererbungslehre. 7.-11. völlig neubearbeitete Auflage. *Berlin* (Gebrüder Borntraeger), 1930. Pp. vii + 478. 6⅝ × 10 inches. 21.50 marks.

BERNSTEIN, FELIX. Über den anthropologischen Wert der Blutgruppen nach Mendes-Corrêa. *Anthropologischer Anzeiger*, Jahrg. VI, Heft 4, pp. 336-338, 1930.

BERNSTEIN, FELIX. Bemerkung zu einer Arbeit von Georg H. M. Waaler: Häufigkeitsberechnungen bei den menschlichen Blutgruppen. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LV, Heft 3, pp. 442-449, 1930.

BERNSTEIN, FELIX. Über die Erblichkeit der Blutgruppen. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LIV, Heft 3/4, pp. 400-426, 1930.

BERNSTEIN, FELIX. Fortgesetzte Untersuchungen aus der Theorie der Blutgruppe. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LVI, Heft 2, pp. 233-273, 1930.

BLUHM, AGNES. Zum Problem "Alkohol und Nachkommenschaft." Eine experimentelle Studie. *München* (J. F. Lehmanns Verlag), 1930. Pp. 87. 7 × 10⅛ inches.

BREUIL, H., and D. PEYRONY. Statuette féminine aurignacienne de Sireuil (Dordogne). (Collection du Dr. L. Capitan). *Revue anthropologique*, Nos. 1-3, 4 pp., 1930.

BURKS, BARBARA S., DORTHA W. JENSEN and LEWIS M. TERMAN. Assisted by Alice M. Leahy, Helen Marshall, Melita H. Oden. Genetic Studies of Genius. Volume III. The Promise of Youth. Follow-up Studies of a Thousand Gifted Children. *Stanford University, Calif.* (Stanford University Press), 1930. Pp. xiv + 508. 5¾ × 8⅝ inches. $6.00.

CHINNERY, E. W. PEARSON. Anthropological Report Nos. 1 and 2. Notes on the Natives of Certain Villages of the Mandated Territory of New Guinea. Visited During the Voyages of the Government Steam Yacht "Franklin," January-March, 1925. And: Notes on the Natives of E Mira and St. Matthias. *London* (Commonwealth Offices, Australia House), undated. Pp. 238. 6 × 9½ inches.

CHINNERY, E. W. PEARSON. Anthropological Report No. 3. Certain Natives in South New Britain and Dampier Straits. *London* (Commonwealth Offices, Australia House), undated. Pp. 102. 6 × 9½ inches.

DAVENPORT, CHARLES B. The mechanism of organic evolution. *Journal of the Washington Academy of Sciences*, Vol. 20, No. 14, pp. 317-331, 1930.

DAVENPORT, CHARLES B. Sex linkage in man. *Genetics*, Vol. 15, pp. 401-444, 1930.

DIEHL, K., and O. v. VERSCHUER. Erbuntersuchungen an tuberkulösen Zwillingen. *Beiträge zur Klinik der Tuberkulose*, Band 75, Heft 1 und 2, pp. 206-215, 1930.

FASTEN, NATHAN. War and eugenics. *Eugenics*, Vol. II, No. 11, 1929.

FASTEN, NATHAN. What do eugenicists aim for? *Eugenics*, Vol. III, No. 6, 1930.

FISCHER, EUGEN. Erbschädigung beim Menschen. *Das Kommende Geschlecht*, Band V, Heft 6, 27 pp., 1930.

FRETS, G. P. Keimgifte. *Archiv für Rassen- und Gesellschaftsbiologie*, Bd. XXIV, pp. 83-96. 1930.

GÜNTHER, HANS F. R. Rassenkunde des jüdischen Volkes. *München* (J. F. Lehmanns Verlag), 1930. Pp. 352. 6 × 8⅞ inches. 11 marks (paper); 13 marks (cloth).

VAN HERWERDEN, M. A., and TH. Y. BOELE. Investigation of blood groups in Holland. *Proceedings Koninklijke Akademie van Wetenschappen te Amsterdam*, Vol. XXXIII, No. 6, 15 pp., 1930.

HOUGH, WALTER. Exploration of ruins in the White Mountain Apache Indian Reservation, Arizona. *Proceedings of the United States National Museum*, Vol. 78, pp. 1-21, 1930.

HUNT, HARRISON R. Biological selection in war. *Eugenics*, Vol. II, No. 11, pp. 1-8, 1929.

HUNT, HARRISON R. Intelligence as a Mendelian character. A suggestion concerning the mode of inheritance of mental ability. *Journal of Heredity*, Vol. XVII, No. 2, pp. 53-58, 1926.

HUNT, HARRISON R. Some Biological Aspects of War. *New York* (The Galton Publishing Co.), 1930. Pp. 118. 6 × 9 inches. $2.00.

JUST, GÜNTHER. Die Grundlagen der menschlichen Vererbungslehre. *Münchener medizinischen Wochenschrift*, No. 22, p. 946; No. 23, p. 986, 1930.

JUST, GÜNTHER. Review of "Physiologische Theorie der Vererbung," Richard Goldschmidt. *Archiv für Rassen- und Gesellschaftsbiologie*, Band 22, Heft 3, pp. 12, 1929.

JUST, GÜNTHER. Ueber multiple Allelie beim Menschen. *Archiv für Rassen- und Gesellschaftsbiologie*, Band 24, pp. 208-227, 1930.

JUST, GÜNTHER. Weiteres über die Ausschaltung des Rezessiven-Überschusses, nebst zwei Tabellen für den praktischen Gebrauch. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LVI, Heft 1, pp. 107-113, 1930.

LOEFFLER, LOTHAR. Röntgenschädigungen der männlichen Keimzelle und Nachkommenschaft. Ergebnisse einer Umfrage bei Röntgenärzten und -technikern. *Strahlentherapie*, Band 34, pp. 735-766, 1929.

MACBRIDE, E. W. Evolution. *New York* (Jonathan Cape and Harrison Smith), 1921. Pp. 122. 4½ × 6¾ inches. 60 cents.

PEYRONY, D. Étude de formes inédites ou très peu connues du Moustérien, leur évolution dans le paléolithique supérieur. *Revue anthropologique*, Vol. 35, Nos. 7-8-9, 19 pp., 1925.

PEYRONY, D. Un fond de hutte de l'époque solutréenne découverte d'un squelette humain à la Madeleine. *Institut International d'Anthropologie. IIIe Session, Amsterdam, 20-29 Septembre 1927.* 6 pp., 1928.

PEYRONY, D. Le gisement préhistorique de La Micoque et ses nouvelles industries, and Présentation de quelques pièces inédites du Magdalénien supérieur. *Association Française pour l'Avancement des Sciences—Le Havre 1929.* 5 pp., 1929.

PEYRONY, D. L'industrie et l'art de la couche des pointes en os à base à biseau simple de Laugerie-Haute. *L'Anthropologie*, T. XXXIX, pp. 361-371, 1929.

PEYRONY, D. Le Moustier. Ses gisements. Ses industries. Ses couches géologiques. *Revue anthropologique*, Nos. 1-3 and 4-6, 50 pp., 1930.

PEYRONY, D. Les peintures murales de la caverne des Merveilles à Rocamadour (Lot). *L'Anthropologie*, T. XXXVI, pp. 401-407, 1926.

PEYRONY, D. Pièces à languette de l'Aurignacien moyen. 2 pp. (no source or date).

PEYRONY, D. Sur quelques pièces intéressantes de la grotte de la roche près de Lalinde (Dordogne). *L'Anthropologie*, T. XL, pp. 19-29, 1930.

PEYRONY, D. Une tête d'ovibos sculptée découverte à Laugerie-Haute (Dordogne). *L'Anthropologie*, T. XXXV, pp. 265-270, 1925.

PEYRONY, D., and J. CAZEDESSUS. Fouilles du second abri de La Roque. *Revue anthropologique*, Vol. 37, Nos. 7-9, 5 pp., 1927.

PEYRONY, D., and COULONGES. Les Tardenoisiens dans l'Agenais. Gisement préhistorique du Martinet (Lot-et-Garonne). *Comptes-Rendu au Congrès de Lyon 1926 de l'Association Française pour l'Avancement des Sciences*, 4 pp., 1927.

POPENOE, PAUL. Practical Applications of Heredity. *Baltimore* (Williams and Wilkins Co.), 1930. Pp. ix + 128. 5 × 7⅜ inches. $1.00.

RUSSELL, E. S. The Interpretation of Development and Heredity. *New York* (Oxford University Press), 1930. Pp. 312. 5⅜ × 8½ inches. $5.00.

SARTON, GEORGE. Discovery of the theory of natural selection. *Isis*, Vol. XIV (1), No. 43, pp. 133-136, 1930.

TODD, T. WINGATE. Practical race improvement. *Brush Foundation Publications*, No. VI, 1930.

v. VERSCHUER, O. Erbuntersuchungen an tuberkulösen Zwillingen. *Medizinische Klinik*, Nr. 27, 4 pp., 1930.

v. VERSCHUER, O. Vom Umfang der erblichen Belastung im deutschen Volke. *Archiv für Rassen- und Gesellschaftsbiologie*, Bd. XXIV, pp. 238-268, 1930.

II. GROUP BIOLOGY

ANNAES DO QUINTO CONGRESSO BRASILEIRO DE HYGIENE. Recife 17 a 22 de Outubro de 1929. Volume II. Sessoes Plenarias. *Rio de Janeiro* (Officinas Graphicas da Inspectoria de Demographia Sanitaria), 1930. 612 pp.

ANONYMOUS. A sound immigration program. *Saturday Evening Post*, Nov. 1, 1930. 1 p.

BURCH, GUY IRVING. Birth control tendency in Europe. *Current History*, August, 1930, pp. 947-950.

BURCH, GUY IRVING. Depopulation. *Eugenics*, Vol. III, No. 7, 1930.

BURCH, GUY IRVING. The future of the city. *Eugenics*, Vol. III, No. 9, 1930.

CARPENTER, NILES. Medical care for 15,000 workers and their families. A survey of the Endicott Johnson Workers Medical Service: 1928. With reports on certain phases of the organization by Nellis B. Foster, Ransom S. Hooker, and Michael M. Davis. Abstract of Publication No. 5. *Committee on the Costs of Medical Care* (910 Seventeenth St., N. W., Washington). 23 pp., 1930.

COMMITTEE ON PUBLIC HEALTH RELATIONS. Report of Activities for the year 1929. *New York Academy of Medicine*. 29 pp. 1930.

COMMITTEE ON SELECTIVE IMMIGRATION, AMERICAN EUGENICS SOCIETY. Immigration program. *Fifth Annual Report*, 1930.

COMMONWEALTH FUND. A Chapter of Child Health. Report of the Commonwealth Fund Child Health Demonstration in Clarke County and Athens, Georgia, 1924-1928. *New York* (Commonwealth Fund Division of Publications), 1930. Pp. v + 169. 6 × 9 inches. $1.00 postpaid.

COMMONWEALTH FUND. Five Years in Fargo. Report of the Commonwealth Fund Child Health Demonstration in Fargo, North Dakota. *New York* (Commonwealth Fund Division of Publications), 1930. Pp. 207. 6 × 9 inches. $1.00 postpaid.

CORWIN, E. H. LEWINSKI. Institutional convalescence. Miscellaneous Contributions on the Cost of Medical Care. No. 1. *The Committee on the Costs of Medical Care* (Washington. D. C.), 8 pp., 1930.

DOWNES, JEAN. The accuracy of the recorded birth statistics in urban and rural areas. *Journal of the American Statistical Association*, Vol. XXIV, pp. 15-27, 1929.

DOWNES, JEAN. Sickness records in school hygiene. *American Journal of Public Health*, Vol. XX, No. 11, pp. 1199-1206, 1930.

DUBLIN, LOUIS I., and ALFRED J. LOTKA. The true rate of natural increase of the population of the United States. Revision on the basis of recent data. *Metron*, Vol. VIII, pp. 107-119, 1930.

GADOW, HANS. Jorullo. The History of the Volcano of Jorullo and the Reclamation of the Devastated District by Animals and Plants. *New York* (The Macmillan Co.); *Cambridge* (Cambridge University Press), 1930. Pp. xviii + 100. 5⅜ × 8½ inches. $3.00 (U. S. A.). 7s. 6d. (England).

GAFAFER, WILLIAM M. Climatic intercorrelations, Greenwich, 1876-1927. *Quarterly Journal of the Royal Meteorological Society*, Vol. LVI, No. 237, pp. 407-411, 1930.

HERSCH, L. Quelques déductions du "principe de la population" de Malthus. *Journal de Statistique et Revue économique suisse*, 66 année, fasc. 2, pp. 207-213, 1930.

HOFFMAN, FREDERICK L. Cancer in Egypt. *Journal of Cancer Research*, Vol. XIV, No. 3, pp. 444-452, 1930.

HULBERT, ARCHER B. Soil. Its Influence on the History of the United States. With Special Reference to Migration and the Scientific Study of Local

History. *New Haven* (Yale University Press), 1930. Pp. xii + 227. 6 × 9 inches. $2.50.

HUNT, HARRISON R. Why birth control? *Eugenics*, Vol. III, No. 4, 2 pp., 1930.

HUTT, C. W. Annual Report of the Medical Officer of Health. The Metropolitan Borough of Holborn. *London*, 1930. Pp. 139.

JOHNS HOPKINS HOSPITAL. Forty-first Report of the Director. For the fiscal year ending June 30, 1930. 156 pp. 1930.

KUCZYNSKI, ROBERT R. Birth Registration and Birth Statistics in Canada. *Washington* (The Brookings Institution), 1930. Pp. xii + 219. 6 × 9 inches. $3.00.

LEAGUE OF NATIONS, HEALTH ORGANISATION. Statistical Handbooks Series: No. 14. The Official Vital Statistics of the Dominion of Canada. *Geneva* (League of Nations, Health Organisation), 1930. Pp. 85. 7¼ × 9½ inches. 60 cents (paper).

MILBANK MEMORIAL FUND. First annual report of the Division of Research. *1928 Annual Report of the Milbank Memorial Fund.* Pp. 135-143.

MILBANK MEMORIAL FUND. Second annual report of the Division of Research. *1929 Annual Report of the Milbank Memorial Fund.* 17 pp.

MUCKERMANN, HERMANN. Differenzierte Fortpflanzung. Eine Untersuchung über 3947 Familien von Professoren deutscher Universitäten und Hochschulen. *Archiv für Rassen- und Gesellschaftsbiologie*, Bd. XXIV, pp. 269-290, 1930.

MUCKERMANN, HERMANN. Neue Forschungen über das Problem der differenzierten Volksvermehrung. *Zeitschrift für induktive Abstammungs- und Vererbungslehre*, Band LIV, pp. 287-295, 1930.

MUSTARD, HARRY S. Cross-Sections of Rural Health Progress. Report of the Commonwealth Fund Child Health Demonstration in Rutherford County, Tennessee, 1924-1928. *New York* (Commonwealth Fund Division of Publications), 1930. Pp. xiii + 230. 6 × 9 inches. $1.00 postpaid.

ON THE STATE OF THE PUBLIC HEALTH. Annual Report of the Chief Medical Officer of the Ministry of Health for the Year 1929. *London* (His Majesty's Stationery Office), 1930. Pp. 240. 6 × 9¾ inches. 3s. 6d. net (paper).

PEARL, RAYMOND, and LOWELL J. REED. The logistic curve and the census count of 1930. *Science*, Vol. LXXII, No. 1868, pp. 399-401, 1930.

PLACE, FRANCIS. Illustrations and Proofs of the Principles of Population. Being the First Work on Population in the English Language Recommending Birth Control. Now Exactly Reproduced. With an Introduction Demonstrating Francis Place as a Founder of the Modern Birth Control Movement, together with Unpublished Letters of Place on Birth Control, Coleridge's Criticisms of Malthus' Views on Birth Control. Critical and Textual Notes by Norman E. Himes. *Boston and New York* (Houghton Mifflin Co.), 1930. Pp. 355. 5½ × 8⅝ inches. $4.50.

RANKIN, W. S. Medicine and public health. Miscellaneous Contributions on the Costs of Medical Care No. 4. *Committee on the Costs of Medical Care* (Washington, D. C.). 8 pp. 1930.

TOBEY, JAMES A. Riders of the Plagues. The Story of the Conquest of Disease. *New York* (Charles Scribner's Sons), 1930. Pp. xv + 348. 5¾ × 8½ inches. $3.50.

TODD, T. WINGATE. The aim and program of the Brush inquiry. No publisher; no date. 5 pp.

TODD, T. WINGATE. Family building: an inquiry into human development. *Brush Foundation Publications* No. 2. 7 pp. 1929.

TODD, T. WINGATE. The herald's staff. *Brush Foundation Publication* No. 3. 8 pp. 1929.

UNITED STATES DEPARTMENT OF LABOR. CHILDREN'S BUREAU. Prenatal Care. Publication No. 4. *Washington* (U. S. Government Printing Office), 1930. Pp. v + 71. 5¾ × 9 inches. 10 cents (paper).

WARNER, ESTELLA F., and GEDDES SMITH. Children of the Covered Wagon. Report of the Commonwealth Fund Child Health Demonstration in Marion County, Oregon, 1925-1929. *New York* (The Commonwealth Fund Division of Publications), 1930. Pp. 12. 6 × 9 inches. $1.00 postpaid.

WIEHL, DOROTHY G. The correction of infant mortality rates for residence. *American Journal of Public Health*, Vol. XIX, No. 5, pp. 495-510, 1929.

WIEHL, DOROTHY G. Some recent changes in the mortality among adults. *Journal of Preventive Medicine*, Vol. 4, No. 3, pp. 215-237, 1930.

WOLFF, GEORG. Die Schutzimpfung gegen Tuberkulose und die natürliche Durchseuchung im Lichte der Statistik. *Deutsche medizinische Wochenschrift*, Nr. 39, 11 pp., 1930.

III. BEHAVIOR

ASSOCIATION AGAINST THE PROHIBITION AMENDMENT. Does Prohibition Pay? *Association Against the Prohibition Amendment* (Washington, D. C.). 46 pp. 1930.

BALDWIN, JAMES M., MARY W. CALKINS, EDOUARD CLAPARÈDE, RAYMOND DODGE, PIERRE JANET, JOSEPH JASTROW, F. KIESOW, WILLIAM MCDOUGALL, CARL E. SEASHORE, C. SPEARMAN, WILLIAM STERN, CARL STUMPF, HOWARD C. WARREN, THEODOR ZIEHEN, H. ZWAARDEMAKER. Edited by Carl Murchison. A History of Psychology in Autobiography. Volume I. *Worcester, Mass.* (Clark University Press). 1930. Pp. xvii + 516. 6 × 9 inches. $5.00.

BONAR, JAMES. Moral Sense. *New York* (The Macmillan Co.), 1930. Pp. 304. 5½ × 8½ inches. $4.00.

BRØGGER, A. W. Ancient Emigrants. A History of the Norse Settlements of Scotland. *New York* (Oxford University Press), 1929. Pp. xi + 208. 5½ × 8¾ inches. $5.00.

BROOKS, C. HARRY. Your Character from Your Handwriting. (With a Foreword by Robert Saudek). *New York* (William Morrow and Co.), 1930. Pp. 207. 5 × 7½ inches. $1.75.

BÜHLER, KARL. The Mental Development of the Child. A Summary of Modern Psychological Theory. *New York* (Harcourt, Brace and Co.), 1930. Pp. xi + 170. 5½ × 8½ inches. $3.00.

CURTIUS, JULIUS. Memorial to Gustav Stresemann. Address by Dr. Julius Curtius, German Minister of Foreign Affairs, to the people of the United States, June 21, 1930, and related matters. *International Conciliation No. 263. Worcester, Mass.* (Carnegie Endowment for International Peace), 1930. Pp. 561-577. 5 cents (paper).

EAGLETON, CLYDE. An attempt to define aggression. *International Conciliation No. 264. Worcester, Mass.* (Carnegie Endowment for International Peace), 1930. Pp. 581-652. 5 cents (paper).

FISHBEIN, MORRIS. Doctors and Specialists. A Medical Revue with a Prologue and a Good Many Scenes. *Indianapolis* (Bobbs-Merrill Co.), 1930. Pp. xi + 118. 5 × 7½ inches. $1.00.

FOGERTY, ELSIE. Stammering. *New York* (E. P. Dutton and Co.), 1930. Pp. 64. 5 × 7¼ inches. 95 cents.

FOREMAN, GRANT; Edited and Annotated by. A Traveler in Indian Territory. The Journal of Ethan Allen Hitchcock, late Major-General in the United States Army. *Cedar Rapids, Iowa* (The Torch Press), 1930. Pp. 270. 6¼ × 9½ inches. $5.00.

GEBHART, JOHN C. Funeral costs. Miscellaneous Contributions on the Costs of Medical Care No. 3. *Committee on the Costs of Medical Care* (Washington, D. C.). 11 pp. 1930.

GUGGENHEIM (JOHN SIMON) MEMORIAL FOUNDATION. Reports of the secretary and treasurer, 1929, 1930. Pp. 117. 1930.

HARDING, T. SWANN. Fads, Frauds and Physicians. Diagnosis and Treatment of the Doctors' Dilemma. *New York* (The Dial Press), 1930. Pp. 409. 5½ × 8⅛ inches. $3.50.

HOLCOMB, RICHMOND C. A Century with Norfolk Naval Hospital, 1830-1930. A Story of the Oldest Naval Hospital, the Medical Department of the Navy and the Progress of Medicine Through the Past One Hundred Years. *Portsmouth, Va.* (Printcraft Publishing Co.), 1930. Pp. 543. 6 × 9¼ inches. $6.50.

HULL, CALLIE, and CLARENCE J. WEST. Doctorates Conferred in the Sciences by American Universities 1929-1930. Compiled for the Research Information Service, National Research Council. Reprint and Circular Series No. 95. *Washington* (National Research Council), 1930. Pp. 49. 6¾ × 9¾ inches. 50 cents (paper).

JOHNSTON, HENRY A. What Rights Are Left. *New York* (The Macmillan Co.), 1930. Pp. x + 177. 5¼ × 7½ inches. $2.00.

JOY, HENRY B. Address of Henry B. Joy at The Crusaders' Dinner, October 15, 1930, Detroit, Michigan. 19 pp. 1930. Copies free on application to *The Crusaders*, Room 610 Book Tower, Detroit.

KING, WILLIAM P. (Edited by). Behaviorism. A Battle Line. *Nashville, Tenn.* (Cokesbury Press), 1930. Pp. 376. 5½ × 8 inches. $2.25.

LATANÉ, JOHN H. The History of the American People. *New York* (Allyn and Bacon), 1930. Pp. xviii + 827. 5½ × 7⅞ inches. $2.00.

MACCALLUM, W. G. William Stewart Halsted, Surgeon. (Introduction by Dr. W. H. Welch.) *Baltimore* (The Johns Hopkins Press), 1930. Pp. xvii + 241. 5½ × 8¼ inches. $2.75.

MCKIM, B. L. We are moving toward armed conflict. *B. L. McKim* (1013 West Waldo St., Independence, Mo.), 16 pp. 1930.

MANUEL, HERSCHEL T. The Education of Mexican and Spanish-Speaking Children in Texas. *Austin, Texas* (The Fund for Research in the Social Sciences), 1930. Pp. ix + 173. 6 × 9 inches. $1.25 net.

MIKLASZEWSKI, JEAN. Le Prof. Dr. A. K. Cajander et ses mérites scientifiques dans le domaine de la typologie forestière. (A l'occasion du cinquantième anniversaire de sa naissance). *Commentationes Forestales 4.* Society of Forestry in Suomi (Finland). 22 pp. 1929.

MORROW, DWIGHT W. For repeal of the Eighteenth Amendment. An address delivered by The Hon. Dwight W. Morrow in Newark, New Jersey, May 15, 1930. *Association Against the Prohibition Amendment* (Washington, D. C.). 8 pp. 1930.

NEW YORK STATE TAX COMMISSION. Federal and state tax systems, 1930. 50 pp. 1930.

RAPPLEYE, W. C. Some medical problems ahead. *Journal of the Association of American Medical Colleges.* 7 pp. 1930.

RAPPLEYE, W. C. Some problems of medical service. *Ohio State Medical Journal,* September, 1930. 6 pp.

REISER, OLIVER L. Humanistic Logic for the Mind in Action. *New York* (Thomas Y. Crowell Co.), 1930. Pp. x + 326. 5½ × 8½ inches. $3.00.

RIGNEY, ELLA H. The importance of cancer publicity. *Hospital Social Service,* Vol. XXII, pp. 219-225, 1930.

RODDIS, LOUIS H. Edward Jenner and the Discovery of Smallpox Vaccination. *Menasha, Wis.* (George Banta Publishing Co.), 1930. Pp. iv + 155. 5 × 7 inches. $1.00.

ROSTAND, JEAN. La Formation de l'Être. Histoire des Idées sur la Génération. *Paris* (Librairie Hachette), 1930. Pp. 222. 4¾ × 7½ inches. 12 francs (paper).

SAIDLA, LEO E., and WARREN E. GIBBS. Science and the Scientific Mind. *New York* (McGraw-Hill Book Co., *Inc.*), 1930. Pp. xiv + 506. 5½ × 8 inches. $3.00.

SARTON, GEORGE. Aristotle and Phyllis. *Isis,* Vol. XIV (1), No. 43, pp. 1-19, 1930.

SCHLAGINHAUFEN, OTTO. Dr. med. Adolf Barth (1872-1930). *Archiv der Julius Klaus-Stiftung für Vererbungsforschung, Sozialanthropologie und Rassenhygiene,* Band IV, Heft ¾, pp. 397-402, 1929.

SHETRONE, HENRY C. The Mound-Builders. A Reconstruction of the Life of a Prehistoric American Race, Through Exploration and Interpretation of Their Earth Mounds, Their Burials, and Their Cultural Remains. *New York* (D. Appleton and Co.), 1930. Pp. xx + 508. 6 × 9¼ inches. $7.50.

SINAI, NATHAN, and MARGARET C. KLEM. The costs of medical care: preliminary report. Miscellaneous Contributions on the Costs of Medical Care No. 2. *The Committee on the Costs of Medical Care,* Washington, D. C. 8 pp. 1930.

SOARES, JOSÉ C. DEM. Rubber. An Economic and Statistical Study. (Preface to the Brazilian Edition by Antonio C. R. de Andrada. Preface to the English Edition by Philip Schidrowitz). *New York* (Richard R. Smith, Inc.), 1930. Pp. xii + 93. 5½ × 9 inches. $3.00.

STRONG, RICHARD P. (Edited by). The African Republic of Liberia and the Belgian Congo. Based on the Observations Made and Material Collected During the Harvard African Expedition, 1926-1927. Vols. I and II. *Cam-*

bridge (Harvard University Press), 1930. Pp. xxxv + 1064. 7½ × 10⅜ inches. $15.00 a set.

TODD, T. WINGATE. The chief. No publisher; no date. 4 pp.

TODD, T. WINGATE. The cultural value of anonymity. Announcement of the gift of the Pol Library to the Cleveland Medical Library Association, Monday, October 21, 1929. 3 pp.

TODD, T. WINGATE. Frontier life. *Brush Foundation Publications* No. 5. 1930.

TODD, T. WINGATE. The medieval physician. *Annals of Medical History*, New Series, Vol. I, No. 6, pp. 615-628, 1929.

TODD, T. WINGATE. Memoriae ergo. No publisher; no date. 2 pp.

UNIVERSITY OF COLORADO STUDIES. Vol. 18, No. 1, containing following articles: A Group of Mystery Plays Found in a Spanish Speaking Region of Southern Colorado, by Edwin B. Place; Studies in Juvenile Delinquency in Colorado (No. 1, One Hundred Boys), by Franklin G. Ebaugh, George S. Johnson and Lawrence W. Woolley; The Mountain Passes of Colorado, by Ralph H. Brown. *Boulder* (University of Colorado), 1930. Pp. 42. 6¾ × 10 inches. $1.00.

WATSON, JOHN B. Behaviorism. *New York* (W. W. Norton and Co., Inc.), 1930. Pp. xi + 308. 6 × 8⅜ inches. $3.00.

IV. SOMATOLOGY AND CONSTITUTION

AREY, LESLIE B. Developmental Anatomy. A Text-Book and Laboratory Manual of Embryology. *Philadelphia* (W. B. Saunders Co.), 1930. Pp. ix + 563. 6½ × 9¾ inches. $6.50.

CARNEGIE INSTITUTION OF WASHINGTON PUBLICATION No. 407. Contributions to Embryology. Volume XXI, Nos. 118 to 125. *Washington* (Carnegie Institution), 1930. Pp. 168 + 29 plates. 9¼ × 11½ inches. $3.75 (paper); $4.75 (cloth).

COOPER, ZOLA K. The relation of the endocrine glands to the growth and distribution of hair. A review of the literature. *Archives of Dermatology and Syphilology*, Vol. 21, pp. 1007-1029, 1930.

DRAPER, GEORGE. Disease and the Man. *New York* (The Macmillan Co.), 1930. Pp. xix + 270. 5¼ × 8 inches. $4.50.

FRIEDENWALD, JULIUS. The human constitution in its relation to gastro-intestinal disorders. *Journal of the American Medical Association*, Vol. 95, pp. 905-910, 1930.

GRAY, HENRY. The Anatomy of the Human Body. Twenty-second Edition, Thoroughly Revised and Re-edited by Warren H. Lewis. *Philadelphia* (Lea and Febiger), 1930. Pp. 1391. 6½ × 10⅛ inches. $10.00.

HALLISY, JAMES E. The muscular variation in the human foot. A quantitative study. General results of the study. I. Muscles of the inner border of the foot and the dorsum of the great toe. *American Journal of Anatomy*, Vol. 45, No. 3, pp. 411-442, 1930.

JORDAN, HARVEY E. A Text-Book of Histology. *New York* (D. Appleton and Co.), 1930. Pp. xxviii + 857. 6 × 8½ inches.

MAXIMOW, ALEXANDER A. Completed and edited by William Bloom. A Text-Book of Histology. *Philadelphia* (W. B. Saunders Co.), 1930. Pp. xiii + 833. 6½ × 9¾ inches. $9.00.

NIPPERT, OLGA. Zur Morphologie und Genese der Fossa temporalis mit besonderer Berücksichtigung der lateralen Orbitalwand. *Zeitschrift für Morphologie und Anthropologie*, Bd. XXIX, Heft 1, pp. 1-82, 1930.

PYLE, S. IDELL. A study of the kyphotic spinal column. *Journal of Bone and Joint Surgery*, Vol. XI, No. 3, pp. 588-592, 1929.

SCHLAGINHAUFEN, OTTO. Die anthropologische Untersuchung an den schweizerischen Stellungspflichtigen. *Bulletin der Schweizerischen Gesellschaft für Anthropologie und Ethnologie*, Jahr. 7, 1930. 7 pp.

SCHLAGINHAUFEN, OTTO. Das Skelett des Johannes Seluner. *Jahrbuch der St. Gallischen Naturwissenschaftlichen Gesellschaft*, Band 65, pp. 323-368, 1929-30.

SYDENSTRICKER, EDGAR, and ROLLO H. BRITTEN. The physical impairments of adult life. General results of a statistical study of medical examinations by the Life Extension Institute of 100,924 white male life insurance policy holders since 1921. The physical impairments of adult life. Prevalence at different ages, based on medical examinations by the Life Extension Institute of 100,924 white male life insurance policy holders since 1921. *American Journal of Hygiene*, Vol. XI, pp. 73-135, 1930.

SYDENSTRICKER, EDGAR, and ROLLO H. BRITTEN. Physical impairments and occupational class. Differential rates based upon medical examinations of 100,924 native-born, adult white insured males. Reprint No. 1404 from the *Public Health Reports*, Vol. 45, No. 34, pp. 1927-1962, 1930.

TODD, T. WINGATE. Age changes in the pubic bone. VIII. Roentgenographic differentiation. *American Journal of Physical Anthropology*, Vol. 14, No. 2, pp. 255-271, 1930.

TODD, T. WINGATE. Comparative youth: the physical aspect. *Child Development*, Vol. I, No. 2, pp. 79-89, 1930.

TODD, T. WINGATE. Growth—the Gipsy. *Brush Foundation Publications* No. 1, 7 pp. 1929.

TODD, T. WINGATE. The Hamann Museum of Comparative Anthropology and Anatomy of Western Reserve University. *Western Reserve University Bulletin*, No. 13, July 1, 1930. 4 pp.

TODD, T. WINGATE. Punching the time-clock of age. *Detroit Proceedings of the Inter-state Postgraduate Medical Association of North America*, pp. 236-239, 1929.

TODD, T. WINGATE. Recent studies in the development of the face. *The International Journal of Orthodontia, Oral Surgery and Radiography*, Vol. XV, No. 12, 20 pp., 1929.

WOLFF, GEORG. Kriegsunterernährung und Grössen-Wachstum. Schulärztlich-anthropometrische Ergebnisse bei Berliner Einschulungsuntersuchungen. *Klinische Wochenschrift*, Jahrg. 9, Nr. 38, pp. 1778-1783, 1930.

V. PHYSIOLOGY AND BIOCHEMISTRY

BESREDKA, A. Le Choc Anaphylactique et le Principe de le Desensibilisation. *Paris* (Masson et Cie), 1930. Pp. 276. 5½ × 9 inches. 30 francs (paper).

CAMERON, A. T. Temperature and life and death. *Transactions of the Royal Society of Canada*, Third Series, Vol. XXIV, Section V, pp. 53-93, 1930.

CRAIB, W. H. The Electrocardiogram. Medical Research Council Special Report Series, No. 147. *London* (His Majesty's Stationery Office), 1930. Pp. 57 + 4 plates. 6 × 9¾ inches. 1s. 3d. net (paper).

CUNY, LOUIS. Le Dosage des Sels Biliaires dans la Bile and le Liquide Duodénal. *Paris* (Masson et Cie), 1930. Pp. 222. 6⅜ × 9¾ inches. 30 francs (paper).

DEDERDING, DIDA. Clinical and Experimental Examinations in Patients Suffering from Mb. Menièri, including a Study of the Problem of Boneconduction. (In two volumes.) Acta Oto-Laryngologica. Supplementum X, XI. *Finland* (Mercators Tryckeri Aktiebolag), 1929. (Each volume contains 4 fasc. and may be obtained through the Editor, Sabbatsbergs Sjukhus, Stockholm). Subscription rate, 25 Swedish crowns per volume. 6⅜ × 9½ inches. No. 1, 156 pp.; No. 2, 213 pp. (paper).

FOÀ, C., A. VALENTI, M. TRUFFI, M. ASCOLI, L. DEVOTO. Fisiologia e Patologia della Pelle. Parte I. *Il Convegno Medico di S. Pellegrino*, 29-30 Giugno 1930. *Soc. an. Terme di S. Pellegrino* (17 Via Castelvetro, Milano). 167 pp., 1930.

FRANK, ROBERT T., and MORRIS A. GOLDBERGER. The female sex hormone. XI. Utilization of the hormone in the normal woman: effect of abnormal kidney permeability in the production of amenorrhea and sterility. *Journal of the American Medical Association*, Vol. 94, pp. 1197-1199, 1930.

FRANK, ROBERT T., R. G. GUSTAVSON, HELEN MCQUEEN and MORRIS A. GOLDBERGER. The simultaneous production of two hormones by the corpus luteum. *American Journal of Physiology*, Vol. 90, No. 3, pp. 727-729, 1929.

HOWELL, WILLIAM H. A Text-Book of Physiology for Medical Students and Physicians. *Philadelphia* (W. B. Saunders Co.), 1930. Pp. 1099. 5¾ × 9⅛ inches. $6.50.

KRAFFT, CARL F. Spirazines. A Type of Chemical Structure Bearing upon the Constitution of Proteins and the Cause of Life. *Washington, D. C., Box 1421* (Carl F. Krafft), 1930. Pp. 54. 5 × 7 inches. 50 cents.

KUENZEL, WILHELMINE and T. WINGATE TODD. Studies in the alimentary tract of man. IV. The reflex effect of heat and cold upon gastric responses. *Journal of Laboratory and Clinical Medicine*, Vol. XV, No. 2, 12 pp., 1929.

LAMB, F. W. An Introduction to Human Experimental Physiology. *New York* (Longmans, Green and Co.), 1930. Pp. xii + 335. 5⅜ × 8½ inches. $4.00.

LEVENTIS, C. Sex Glands Function and the Human Life. *911 Kresge Bldg., Detroit* (C. Leventis), 1930. Pp. 132. 5¼ × 7¾ inches.

LUCKIESH, M. Artificial Sunlight. Combining Radiation for Health with Light for Vision. *New York* (D. Van Nostrand Co., Inc.), 1930. Pp. 254. 6 × 9 inches. $3.75.

RICHTER, CURT P. High electrical resistance of the skin of new-born infants and its significance. *American Journal of Diseases of Children*, Vol. 40, pp. 18-26, 1930.

TODD, T. WINGATE. Behavior patterns of the alimentary tract. *American Journal of Surgery*, New Series, Vol. VII, No. 4, pp. 487-488, 1929.

TODD, T. WINGATE, and WILHELMINE KUENZEL. Studies in the alimentary tract of man. I. The attainment of reliability in gastric responses. *Journal of Laboratory and Clinical Medicine*, Vol. XIV, No. 11, 16 pp., 1929.

TODD, T. WINGATE, and WILHELMINE KUENZEL. Studies in the alimentary tract of man. II. Stabilization of gastric reaction patterns. *Journal of Laboratory and Clinical Medicine*, Vol. XIV, No. 12, 12 pp., 1929.

TODD, T. WINGATE, and WILHELMINE KUENZEL. Studies in the alimentary tract of man. III. The gastric responses to milk and buttermilk. *Journal of Laboratory and Clinical Medicine*, Vol. XV, No. 1, 8 pp., 1929.

TODD, T. WINGATE, and WILHELMINE KUENZEL. Studies in the alimentary tract of man. V. Disturbances of central origin in gastric responses. *Journal of Laboratory and Clinical Medicine*, Vol. XV, No. 2, 11 pp., 1929.

TODD, T. WINGATE, and MARGARET E. ROWLANDS. Studies in the alimentary canal of man. VI. Emotional interference in gastric behavior patterns. *Journal of Comparative Psychology*, Vol. X, No. 2, pp. 167-188, 1930.

VI. PATHOLOGY, CLINICAL MEDICINE AND SURGERY

BARBER, C. G. The detailed changes characteristic of healing bone in amputation stumps. *Journal of Bone and Joint Surgery*, Vol. XII, No. 2, pp. 353-359, 1930.

BARBER, C. G. Immediate and eventual features of healing in amputated bones. *Annals of Surgery*, Vol. 90, No. 6, pp. 985-992, 1929.

ELMER, WARREN P., and W. D. ROSE. Physical Diagnosis. *St. Louis* (The C. V. Mosby Co.), 1930. Pp. 903. 6 × 9 inches. $10.00.

HEGNER, ROBERT. Minute animal parasites of man. *Scientific Monthly*, Vol. XXX, pp. 251-257, 1930.

HEGNER, ROBERT, and H. J. CHU. A comparative study of the intestinal protozoa of wild monkeys and man. *American Journal of Hygiene*, Vol. XII, No. 1, pp. 62-108, 1930.

HEIDENHAIN, LOTHAR. Über das Problem der bösartigen Geschwülste. Eine experimentelle und theoretische Untersuchung. Zweiter, abschliessender Band. *Berlin* (Julius Springer), 1930. Pp. vi + 207. 10 × 13 inches. 42 marks (paper); 47.60 marks (cloth).

MCCALLUM, J. T. C., and L. G. ZERFAS. Sodium iso-amyl-ethyl barbiturate. Sodium amytal in the preliminary preparation of patients for regional anesthesia. *American Journal of Surgery*, Vol. VIII, No. 1, pp. 39-43, 1930.

ROBBINS, A. R., J. T. C. MCCALLUM, A. M. MENDENHALL and L. G. ZERFAS. The use of sodium iso-amylethyl barbiturate (sodium amytal) in obstetrics. *American Journal of Obstetrics and Gynecology*, Vol. XVIII, No. 3, p. 406, 1929.

SYDENSTRICKER, EDGAR, and FRANK W. NOTESTEIN. Differential fertility according to social class. A study of 69,620 white married women under 45 years of age based upon the United States census returns of 1910. *Journal of the American Statistical Association*, Vol. XXV, pp. 9-32, 1930.

VALLERY-RADOT, PASTEUR, and MLLE. V. HEIMANN. Hypersensibilités Spécifiques dans les Affections Cutanées. Anaphylaxie. Idiosyncrasie. *Paris* (Masson et Cie), 1930. Pp. 146. 6 × 9⅜ inches. 25 francs (paper).

WAELKENS, D. Les Embryomes du Testicule. Étude Critique. Travail des Laboratoires du Docteur A. Peyron (Institut Pasteur, Paris). *Paris* (P. et A. Davy), 1929. Pp. 139.

WILMER, W. H. Diseases of the eye in old age. *Archives of Ophthalmology*, Vol. 1, pp. 42-62, 1929.

VII. METHODOLOGY

BARLOW'S TABLES of Squares, Cubes, Square Roots, Cube Roots, and Reciprocals of All Integer Numbers up to 10,000. Third Edition. Edited by L. J. Comrie. *London* (E. and F. N. Spon, Ltd.), 1930. Pp. xii + 208. 5⅜ × 8½ inches. 7s. 6d. net.

BERNSTEIN, FELIX. Zur Kritik der von S. Wellisch angewandten mathematischen Methoden in der Blutgruppenforschung. *Zeitschrift für Rassenphysiologie*, Bd. 3, Heft 1, pp. 27-44, 1930.

BERNSTEIN, FELIX. Über die Anwendung der Steinerschen Fläche in der Erblichkeitslehre, insbesondere in der Theorie der Blutgruppen. *Zeitschrift für angewandte Mathematik und Mechanik*, Band 9, p. 503, 1929.

BERNSTEIN, FELIX. Ueber die Ermittlung und Prüfung von Gen-Hypothesen aus Vererbungsbeobachtungen am Menschen und über die Unzulässigkeit der Weinberg'schen Geschwistermethode als Korrektur der Auslesewirkung. *Archiv für Rassen- und Gesellschaftsbiologie*, Band 22, Heft 3, pp. 241-244, 1929.

BERNSTEIN, FELIX. Über den mittleren Fehler der Potenzmomente. *Blätter für Vers.-Mathematik und verwandte Gebiete*, Band 30, Heft 3, pp. 365-377, 1930.

BERNSTEIN, FELIX. Ueber die Unzulässigkeit der Weinbergschen Geschwistermethode. *Archiv für Rassen- und Gesellschaftsbiologie*, Band 23, Heft 2/3, pp. 285-290, 1930.

BOWMAN, HENRY ADELBERT. The color-top method of estimating skin pigmentation. *American Journal of Physical Anthropology*, Vol. 14, No. 1, pp. 59-72, 1930.

FIALA, GRACE F. Preparation of hair for cross-section examination. *American Journal of Physical Anthropology*, Vol. 14, No. 1, pp. 73-74, 1930.

HAZEMANN, R. H. Introduction à l'étude des méthodes statistiques utilisables en hygiène. *Annales d'Hygiène, Publique, Industrielle et Sociale*, 8e Année, No. 6, pp. 13, 1930.

PEARL, RAYMOND. Introduction to Medical Biometry and Statistics. Second Edition, Revised and Enlarged. *Philadelphia* (W. B. Saunders Co.), 1930. Pp. 459. 6 × 9⅛ inches. $5.50.

VIII. MISCELLANEOUS

BARROWS, HENRY R. College Biology. *New York* (Richard R. Smith, Inc.), 1930. Pp. xv + 414. 5½ × 8½ inches. $3.00.

DRACHMAN, JULIAN M. Studies in the Literature of Natural Science. *New York* (The Macmillan Co.), 1930. Pp. xi + 487. 5¾ × 8½ inches. $4.00.

JEANS, SIR JAMES. The Mysterious Universe. *New York* (The Macmillan Co.), 1930. Pp. ix + 163. 5½ × 8 inches. $2.25.

KINGSLEY, NATHAN H., and EDWARD J. MENGE. Laboratory Studies, Demonstrations, and Problems in Biology. *Milwaukee* (Bruce Publishing Co.), 1930. Pp. 208. 8½ × 11 inches. $1.28 (paper).

KOPPANYI, THEODORE. The Conquest of Life. *New York* (D. Appleton and Co.), 1930. Pp. xii + 263. 5 × 7½ inches. $2.00.

RÁDL, EMANUEL. The History of Biological Theories. Translated and adapted from the German by E. J. Hatfield. *New York* (Oxford University Press), 1930. Pp. xii + 408. 5½ × 8½ inches. $6.00.

SMALLWOOD, WILLIAM M. A Text-book of Biology. For Students in General, Medical and Technical Courses. *Philadelphia* (Lea and Febiger), 1930. Pp. 470. 5¾ × 9⅛ inches. $4.00 net.

STEDMAN, THOMAS L. A Practical Medical Dictionary of Words Used in Medicine with Their Derivation and Pronunciation, Including Dental, Veterinary, Chemical, Botanical, Electrical, Life Insurance and Other Special Terms; Anatomical Tables of the Title in General Use, and Those Sanctioned by the Basle Anatomical Convention; Pharmaceutical Preparations, Official in the U. S. and British Pharmacopœias and Contained in National Formulary, and Comprehensive Lists of Synonyms. *New York* (William Wood and Co.), 1930. Pp. xi + 1220. 6 × 9½ inches. $7.50 net.